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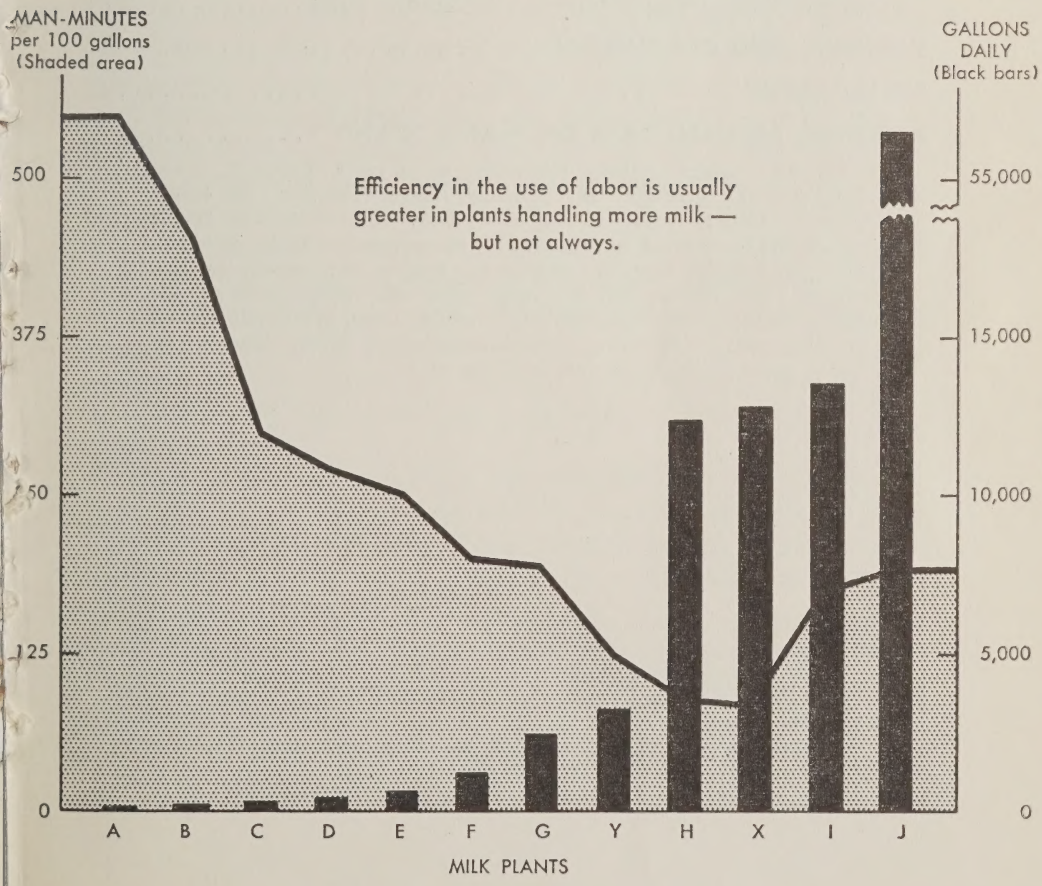
Measuring Efficiency of

MILK PLANT OPERATION

By R. W. Bartlett and F. T. Gothard

Bulletin 560
UNIVERSITY OF ILLINOIS · AGRICULTURAL EXPERIMENT STATION



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Urbana, Illinois November, 1952

Publications in the Bulletin series report the results of investigations made or sponsored by the Experiment Station

MEASURING EFFICIENCY OF MILK PLANT OPERATIONS

By R. W. Bartlett and F. T. Gothard[1]

WHEN ANYONE BUYS A BOTTLE OF MILK, to all appearances he is completing a simple sales transaction. He pays one man so many cents for so many fluid ounces of nutrition. Actually he is paying not one man but several. The farmer who produces the milk is responsible for part of its cost. The dealers who handle it are also responsible; they must process, bottle, store, deliver, and sell the milk. The price of a bottle of milk thus is influenced by both the efficiency of milk production and the efficiency of milk-plant operations.

For several decades major attention in the dairy departments of our land-grant colleges has been centered upon ways of increasing the efficiency of milk production. The usefulness of such studies is evidenced by the fact that the average production per cow in Illinois, for example, is now 61 percent higher than that of fifty years ago and is 30 percent higher than that of twenty-five years ago.[2] Increased efficiency in production undoubtedly has been one of the factors contributing to high per-capita sales of milk in the United States.

Until recently, however, relatively little attention was devoted to studies on how to increase the efficiency of milk distribution, even though in many markets, dealers' gross margins make up more than half the price consumers pay for milk. In 1949 consumers in ten Illinois markets paid an average price of 17.8 cents per quart for milk at stores and 19.7 cents for home-delivered milk.[3] Farmers received 47 percent of the store price paid by consumers and 42 percent of the home-delivered price. From the viewpoint of the consumer, studies centered upon increasing the efficiency of milk distribution are even more important than those aimed at securing lower costs of farm production.

What factors are involved in efficient milk distribution? Why are some plants more efficient than others? How can a manager or plant owner increase the efficiency of his plant? It is with these questions in mind that the University of Illinois has during the past few years

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[1] R. W. Bartlett, Professor of Agricultural Economics; and F. T. Gothard, formerly Assistant in Agricultural Economics. This study was supported in part by funds authorized by the Research and Marketing Act of 1946.

[2] Data from *Historical Census of the United States, 1789-1945,* U. S. Dept. Agr. and U. S. Bur. of Census; and from Illinois State Department of Agriculture.

[3] Illinois Farm Economics, October-November, 1950, pages 1073-1084.

carried on studies to measure efficiency in the use of labor, space, electric power, and steam power for the principal operations of market-milk plants. Measurements have been made both in physical units and in money units.

Two plants, Plant X in Illinois and Plant Y in Minnesota, were selected for detailed analysis. They were chosen because in 1946 they were operating at a high degree of efficiency. The operations of Plant X were found to be the most efficient of those for all plants for which data have been available to the authors.[1] Plant Y, whose volume was less than that of Plant X, operated somewhat less efficiently.

Plants X and Y were accessible to the authors, and their personnel were willing to cooperate in the investigation. The managers of both plants broke down man-hours for various operations and provided exact figures on use of labor, space, and equipment, and on operating costs. As a result of this cooperation, the authors were able to study the efficiency of two well-operated milk plants through a first-hand survey.

For checking purposes two earlier reports have been used, one based on six Connecticut plants and one on four Washington plants. Figures on man-hours and on operating costs taken from these studies highlight those obtained from Plants X and Y.

Since this study aims to provide practical aid as well as to assemble and analyze pertinent statistics, space is provided in Tables 2, 3, 5, and 6 where plant owners and managers may record their own figures on plant operations and thus locate their weaknesses by comparing their figures with those for Plants X and Y.

CHANGES AFFECTING THE DISTRIBUTION OF MILK

With the widespread distribution of milk supplies, often to places remote from the milkshed, and with the rapid urbanization of our country, milk distribution is no longer a simple matter. It is complicated by problems in transportation, in processing, in store sales, in bottling and packaging, and in meeting trade barriers. Some problems, especially those involved in attaining maximum efficiency of milk-plant

[1] In 1943 the senior author assembled unit costs of milk-plant operation for over 1,000 milk plants operated by approximately 700 different companies. Some 200 of these costs were found to be reasonably comparable. A breakdown and analysis of the costs for each plant showed that the most efficient plants were those which operated a 100-percent wholesale business and sold milk exclusively in paper containers. See *The Milk Industry,* by R. W. Bartlett, pages 46 to 49 and 265 to 269.

operation, have not been wholly solved. Others have been so well met that in Illinois and many other states rapid changes are occurring in the processing and distribution of milk.

Widespread growth of improved roads. Milk transportation has evolved through the milk wagon and the milk train to the milk truck. Trucks require good roads. During the past thirty years, Illinois has made much progress in building all-weather roads capable of holding up trucks.

Increased distribution of milk through stores. During the past twenty-five years, the proportion of store sales to total sales of milk has increased greatly. By 1930, 30 percent of the total milk sales in the United States was through stores; by 1950, 45 percent. In some large markets such as New York, Chicago, and Los Angeles, store sales are now over 60 percent of total milk sales.

The shift from home delivery to store sales has frequently been accompanied by a rapid increase in per-capita sales. In Chicago, for instance, the per-capita sales in 1950 averaged 0.77 pint daily, as compared with 0.54 pint in 1934. Lower store prices and quantity discounts, along with an increased consumer income, were among the factors causing this 43-percent increase in the per-capita sales of milk.[1]

Increased use of paper containers. The increase in use of the single-service container has contributed to the expansion of store sales. According to information compiled by the Pure-Pak division of Ex-Cell-O Corporation, 71 percent of the milk sold throughout the United States by grocery stores in 1950 was packaged in paper containers.[2] Only 29 percent was packaged in glass bottles. Studies made in California showed that 85 percent of all milk sold through stores in 1945 in that state was sold in fiber containers.[3]

The use of paper containers for milk has increased greatly since 1940. According to recent studies, 4.8 percent of all milk sold in villages and cities in 1940 was packaged in paper containers.[4] By 1950 this percentage had increased to 31.2.

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[1] Based upon data obtained from the Chicago Federal Milk Market Administrator.

[2] Letter from George Scott, vice-president in charge of Pure-Pak sales, July 31, 1951.

[3] Blackburn, R. W. "Streamlining Plant Operations and Store Distribution of Milk." Dairy Marketing Conference, University of Illinois, January 28, 1947. AE2443, p. 24. (mimeo.)

[4] Data compiled by an executive of the Borden Company, New York, and published in 1951 by the Pure-Pak division of the Ex-Cell-O Corporation (Detroit).

The use of single-service containers is rapidly widening the area in which milk can be economically distributed from one plant. Several Illinois dealers are regularly distributing milk in paper containers to many markets located as far as 200 miles from the bottling plant. As a result of widening of marketing areas, no local market in Illinois is free from either actual or potential competition from milk produced or bottled outside its local milkshed. For example, the Champaign-Urbana market, which formerly received all of its milk from local producers, is now regularly receiving milk packaged in paper containers from Bloomington, Chicago, Danville, Peoria, and Taylorville. This change has come about since 1948.

Action of the courts in breaking down trade barriers. In the past, many municipalities have enacted sanitary ordinances which have acted to prevent intermarket shipments of milk. The city of Waukegan, for example, had a comprehensive milk ordinance requiring that all milk sold in the city, except during emergencies, be produced and pasteurized in Lake county. Such an ordinance, even when intended as a health measure, frequently becomes a trade barrier protecting local dealers and farmers and preventing the benefits of free competition to consumers.

In three specific markets, including Waukegan, dealers wanting more efficient distribution of milk have brought cases before the courts of Illinois. In deciding these cases, the Illinois Supreme Court has upheld the legality of intermarket shipments of milk.

MAJOR FACTORS AFFECTING EFFICIENCY IN MARKET-MILK PLANTS

Analysis of the use of labor, space, electric power, and steam power by specific plants indicates two facts of major importance: (1) efficiency in the use of labor tends to increase as volume increases, and (2) volume alone is not a dependable measure of efficiency.

That labor requirements tended to decrease as volume increased was brought out by a comparison of Plants X and Y and four Washington and six Connecticut plants (Table 1). Plant X handled 12,750 gallons of milk daily, over two hundred times the volume of the Connecticut plant designated A. The unit requirements of man-minutes (86 per 100 gallons) for Plant X were only one-sixth of those of the Connecticut plant.

Space requirements also tended to decrease as volume increased.

Table 1. — Labor, Space, Electric Power, and Heat Requirements in Twelve Market-Milk Plants[a]

Plant	Gallons of milk per day	Man-minutes per 100 gallons	Square feet of floor space per 100 gallons	Electric power (horsepower-hours) per 100 gallons	British thermal units[b] (1,000) per 100 gallons	Number of products handled
A	60	550	422	31.3	171.7	..
B	100	420	321	25.4	156.0	..
C	200	300	284	24.0	138.5	..
D	400	270	286	16.4	139.0	..
E	600	250	274	15.3	132.0	..
F	1,200	200	220	12.4	122.4	..
G	2,452	193	283	....	.....	14
Y	3,250	123	292	18.1	90.9	4
H	12,260	88	209	....	.....	8
X	12,750	86	152	14.2	73.6	4
I	13,490	177	262	....	.....	18
J	56,400	191	...	....	.....	41

[a] Data for plants A to F from Storrs Agricultural Experiment Station Bulletin 259, June 1948, p. 27; data for plants G, H, I, and J from *The Milk Industry* (Bartlett), p. 232; data for plants X and Y from plants used for detailed study. Plants A to F handled milk exclusively in glass containers and had both a wholesale and retail business. Plants G and I handled milk exclusively in glass and had a 100-percent retail business. Plants Y, H, and X handled milk exclusively in paper and had a 100-percent wholesale business. Plant I handled milk in both glass and paper containers and had both a wholesale and a retail business.

[b] British thermal unit (B.t.u.) is the amount of heat required to raise one pound of water one degree Fahrenheit.

Plant X used 152 square feet of floor space per 100 gallons of milk, or a little more than one-third the space required by Plant A, 422 square feet.

The same situation existed for electric- and steam-power requirements. Plant X used 14.2 horsepower-hours per 100 gallons of milk with a volume of 12,750 gallons per day. Plant Y required 18.1 horsepower-hours with a volume of 3,250 gallons of milk per day, while Plant A, with the least volume of all the plants examined, 60 gallons of milk per day, used 31.3 horsepower-hours per 100 gallons.

Volume alone is not a dependable measure of efficiency. Plant X handled daily only one-fourth (12,750 gallons) of the volume handled daily by Plant J in Washington (56,400 gallons), and yet Plant X had less than half the unit labor requirements of Plant J, which were 191 man-minutes per 100 gallons.

The lower unit labor requirements of Plant X may be attributed in part to the following factors:

1. Plant X was constructed so that modern equipment could be arranged to make the most efficient use of labor. Plant J, however, as its business grew, had built one addition after another and had several different floor levels. It was almost impossible to arrange equipment in Plant J so as to use labor efficiently.

2. Plant X handled only 4 items while Plant J handled 41. Unit labor requirements tend to increase as the number of items handled increases.

3. Plant X handled milk only in paper containers. In contrast, Plant J handled both glass and paper containers. Unless a plant is built expressly to handle both glass and paper containers, a combined operation frequently results in less efficient use of labor since it is difficult to integrate the two types of equipment and two kinds of activity.

Some plants use their space more efficiently than others with an equivalent or greater volume. Plant X, with about the same volume as Plant I in Washington, used 40 percent less space per 100 gallons of milk than Plant I. Plant Y, handling 3,250 gallons per day, was less economical in use of space than Plant F in Connecticut. Plant F, with only three-eighths of the volume of Plant Y, used 25 percent less space per 100 gallons of milk than Plant Y.

Although unit electric-power requirements were lower for Plant X than for all four Washington plants and five of the Connecticut plants, they were slightly higher than for Plant F. This is a departure from the trend for increasing volume to result in greater economy, for Plant X handled about ten times the volume of Plant F.

Steam-power requirements, however, for all plants tended to decrease as volume increased.

The facts shown for labor, space, and electric power coincide with those disclosed in other studies. One study showed that unit labor costs for one of the largest dealers in the market were 13 percent higher than the market average for store sales and 31 percent above the market average for home deliveries of milk.[1] Another study showed that distribution costs of 11 large distributors averaged 8 percent higher than those of all (117 dealers) included in this study.[2]

OPERATIONS OF PLANTS X AND Y

The plant manager who thinks his operating overhead is too high and wants to reduce it must determine which operations are being done efficiently and which are being done inefficiently. A simple inspection of his own plant is not enough, and it may be difficult for him to visit other plants. Yet he needs a standard of comparison. Such a standard is presented here in the detailed study of each of the major

[1] *The Milk Industry,* by R. W. Bartlett, p. 57.

[2] From Maine Agricultural Experiment Station Bulletin 451. 1947.

operations of two north-central plants, Plants X and Y. A plant manager can check his own operations against those of two very efficient plants.

How this works out is shown by two examples. A former student of the senior author used the efficiency standards of Plant X in studying a Chicago dairy of similar size. Later he became superintendent of the plant. Knowing that the electric-power requirements were considerably higher than those of Plant X, he hired an engineering firm to make a special study of how horsepower requirements in his plant could be reduced.

In another case, a plant manager used the standards set forth in this study as a basis for an analysis of his own plant. He later reported[1] what he had done to increase the efficiency of his dairy. First, finding that his transportation and receiving-station costs were too high, he closed a receiving station and rerouted his milk routes to eliminate unnecessary mileage. This made possible a 12-cent saving per 100 pounds of milk. Second, finding his clean-up costs out of line, he invited the company furnishing his chemicals to inspect his plant practices. He was able to reduce both material costs and labor costs. In conclusion, he pointed out that (1) old equipment used on the basis of depreciation rates, (2) awkward plant layouts, and (3) the packaging of too many items "can creep up on an operator and catch him eventually."

What these two men have done, any plant operator can do. Since Plant X is extremely efficient, the most efficient of all when compared with the four Washington and six Connecticut plants, and Plant Y is only slightly less efficient, an analysis of their operations can be helpful not only in analysis of other plants, but also in setting standards of efficiency for specific operations.

Labor Requirements and Labor Costs

Plant X used an average of 859 man-minutes per 1,000 gallons of milk, and Plant Y used 43 percent more, 1,228 man-minutes (Table 2). Plant X was more efficient in use of labor than the four Washington and six Connecticut plants also (see front cover and Table 1). Plant H came closest to Plant X in number of man-minutes used per 1,000 gallons of milk with 880. Plant A was at the other end of the scale, using 5,500 man-minutes per 1,000 gallons. This amount was over six times the unit labor requirements of Plant X.

[1] Talk given at Dairy Marketing Conference, University of Illinois, February 7, 1951. AE2792, pp. 3-6. (mimeo.)

Table 2. — Summary of Daily Labor and Labor Costs for Plants X and Y[a]

	Plant X	Plant Y	Your own plant
Receiving			
Total man-minutes	676	411	
Man-minutes per 1,000 gallons	53.0	126.4	
Cost per hour	$ 1.46	$ 1.17	
Cost per 1,000 gallons	$ 1.29	$ 2.47	
Clarifying and filtering			
Total man-minutes	265	17	
Man-minutes per 1,000 gallons	20.6	5.2	
Cost per hour	$ 1.46	$ 1.06	
Cost per 1,000 gallons	$ .51	$ .09	
Pasteurizing			
Total man-minutes	2,286	713	
Man-minutes per 1,000 gallons	179.2	219.4	
Cost per hour	$ 1.54	$ 1.25	
Cost per 1,000 gallons	$ 4.59	$ 4.57	
Homogenizing			
Total man-minutes	256	220	
Man-minutes per 1,000 gallons	20.2	67.6	
Cost per hour	$ 1.47	$ 1.20	
Cost per 1,000 gallons	$ .49	$ 1.35	
Bottling			
Total man-minutes	3,591	973	
Man-minutes per 1,000 gallons	281.7	299.4	
Cost per hour	$ 1.48	$ 1.27	
Cost per 1,000 gallons	$ 6.97	$ 6.35	
Bottle-case cleaning and storage			
Total man-minutes	811	77	
Man-minutes per 1,000 gallons	63.7	23.7	
Cost per hour	$ 1.31	$ 1.06	
Cost per 1,000 gallons	$ 1.39	$ .42	
Bottle-case filling and storage			
Total man-minutes	3,070	1,581	
Man-minutes per 1,000 gallons	240.7	486.5	
Cost per hour	$ 1.38	$ 1.14	
Cost per 1,000 gallons	$ 5.53	$ 9.25	
Totals			
Total time	10,955	3,992	
Man-minutes per 1,000 gallons	859	1,228	
Cost per hour	$ 1.45	$ 1.20	
Cost per 1,000 gallons	$20.76	$27.44[b]	
Cost per quart, cents	.519	.686	
Daily volume, gallons	12,750	3,250	

[a] From Tables 8 through 17.

[b] Includes administrative costs in addition to direct costs. No data on hours of labor for administration were available.

Both Plant X and Plant Y received daily the amounts of milk needed for bottling operations. Plant X, however, received milk from tank trucks while milk came to Plant Y in 10-gallon cans. Plant Y's unit labor requirements for receiving were more than double those of Plant X.

The principal operation in which Plant X proved more efficient in the use of labor than Plant Y was in bottle-case filling and storage.[1] Plant Y used 486 man-minutes per 1,000 gallons in this operation, or about double the time used by Plant X, 241 man-minutes (Table 2).

[1] Officials of Plant X are now working on a method by which cases will be packed by machinery in order to eliminate labor for this operation.

Plant X had a higher speed for bottling milk than Plant Y. As a result, the employees worked faster and accomplished more than in Plant Y. Plant X was likewise more efficient than Plant Y in homogenizing milk, using less than one-third the unit labor requirements of Plant Y.

Although both plants used the high-temperature short-time method of pasteurization, Plant Y used 219 man-minutes per 1,000 gallons for pasteurizing milk, or 28 percent more than Plant X.

Plant Y was more efficient than Plant X in bottle-case cleaning and storage, using only three-eighths as much labor and half as much space. Through a compact arrangement of its equipment, Plant Y saved many steps for its employees.

Labor is the most costly factor in any milk plant, other than the cost of bottles and bottler rentals. In Plant X, labor ran $20.76 per 1,000 gallons, or 28.8 percent of total plant outlay and 72 percent of costs other than those for bottles and bottler rentals.

In most markets milk dealers pay the prevailing wage rates for different types of work, so an individual company has little control over the rate paid. In the market where Plant X was located, for example, the wage rate was materially higher than that where Plant Y was located. Plant X paid an average rate of $1.45 per hour, while Plant Y averaged $1.20 per hour. Though Plant X had a higher wage rate than Plant Y, its unit cost for labor was 24 percent less than that of Plant Y.

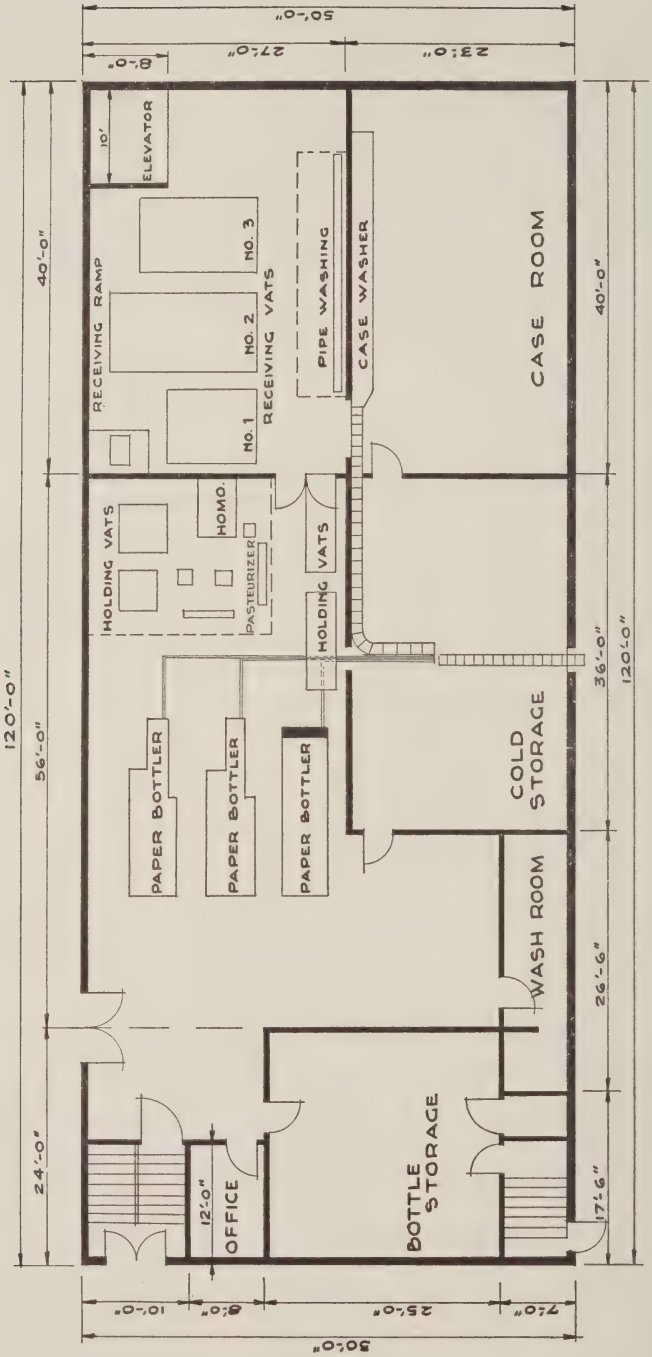
A manager who makes a careful analysis of every operation in his plant will generally find that he can reduce labor costs.

Space Requirements and Space Costs

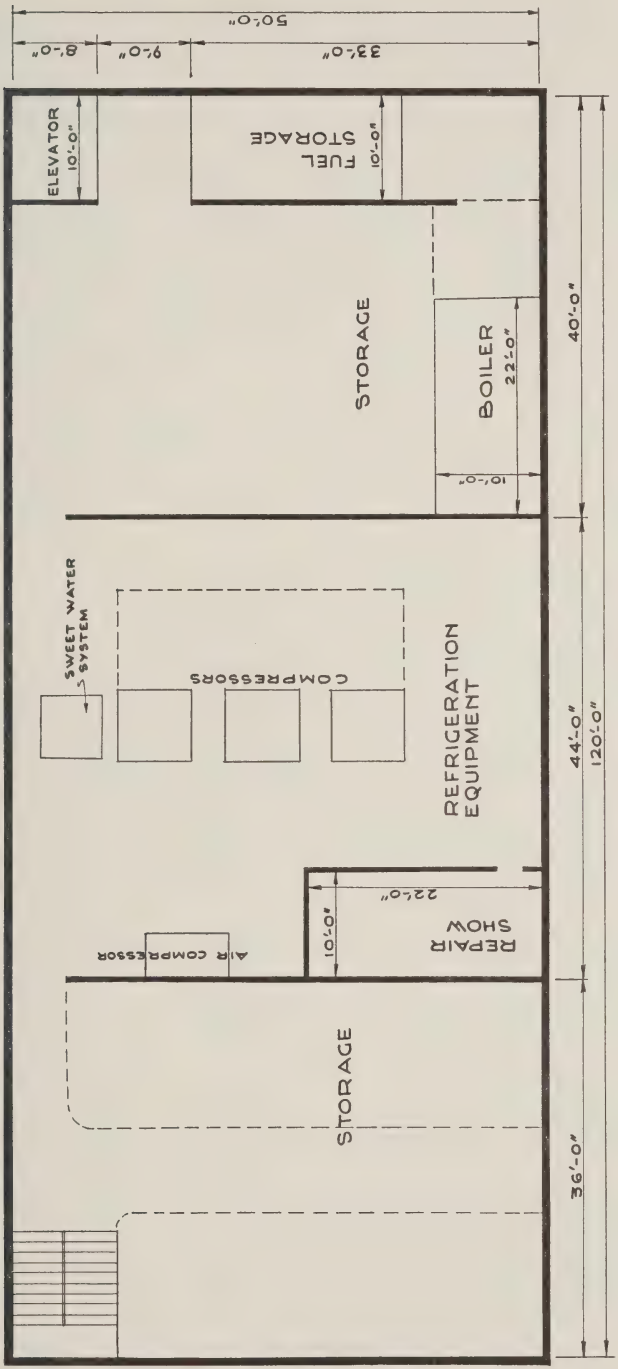
Efficient use of space in a milk plant means a lower unit cost of capital investment both in building and equipment, more efficient use of machinery through greater concentration, and a saving of man-hours because of convenient working conditions.

Plant X operated two shifts of eight hours daily. A third shift came at night for clean-up operations. With this concentrated labor force, Plant X used its floor space very efficiently, averaging 682 square feet per 1,000 gallons of milk daily, or about half the space requirements of Plant Y, which were 1,334 square feet (Table 3). Only two of the ten Washington and Connecticut plants used more space per 1,000 gallons than Plant Y.

By piping its milk directly from tank trucks, Plant X also made substantial savings in the space required for receiving milk. Its unit



Layout of the main floor of Plant X. (Fig. 1)



Layout of the basement of Plant X. (Fig. 2)

space requirements for this operation were about one-fourth those of Plant Y, where space was needed for receiving and storing milk cans.

In bottle-case filling and storage, the working of two shifts resulted in substantial space savings for Plant X. Not only could two men use the space normally used by one, but twice the number of bottle cases could be filled and stored. Through this efficient use of space and labor, Plant X was able to take care of its bottle-case filling and storage at the rate of 85 square feet of floor space per 1,000 gallons of milk daily, or about one-third the rate for Plant Y (266 square feet).

Plant Y, however, was more efficient than Plant X in its use of space for bottle-case cleaning and storage and for bottling. Plant Y

Table 3. — Summary of Space and Space Costs[a]

	Plant X	Plant Y	Your own plant
Receiving			
Total square feet	976	846	
Square feet per 1,000 gallons handled daily	76.5	260.3	
Cost per 1,000 square feet	$ 2.688	$ 2.560	
Cost per 1,000 gallons	$ .206	$ .666	
Clarifying and filtering			
Total square feet	317	48	
Square feet per 1,000 gallons handled daily	24.9	14.8	
Cost per 1,000 square feet	$ 2.688	$ 2.560	
Cost per 1,000 gallons	$ .067	$ .038	
Pasteurizing			
Total square feet	1,435	1,412	
Square feet per 1,000 gallons handled daily	112.5	434.4	
Cost per 1,000 square feet	$ 2.688	$ 2.560	
Cost per 1,000 gallons	$ .303	$ 1.112	
Homogenizing			
Total square feet	168	166	
Square feet per 1,000 gallons handled daily	13.2	51.1	
Cost per 1,000 square feet	$ 2.688	$ 2.560	
Cost per 1,000 gallons	$ .035	$ .131	
Bottling			
Total square feet	3,684	870	
Square feet per 1,000 gallons handled daily	288.9	267.6	
Cost per 1,000 square feet	$ 2.688	$ 2.560	
Cost per 1,000 gallons	$ .776	$ .685	
Bottle-case cleaning and storage			
Total square feet	1,035	128	
Square feet per 1,000 gallons handled daily	81.2	39.4	
Cost per 1,000 square feet	$ 2.688	$ 2.560	
Cost per 1,000 gallons	$ .218	$ .101	
Bottle-case filling and storage			
Total square feet	1,082	866	
Square feet per 1,000 gallons handled daily	84.9	266.4	
Cost per 1,000 square feet	$ 2.688	$ 2.560	
Cost per 1,000 gallons	$ .228	$ .682	
Totals			
Total investment	$65,740	$38,150	
Total floor space (adjusted) square feet	8,697	4,336	
Floor space (adjusted) per 1,000 gallons handled daily, square feet	682	1,334	
Daily cost per 1,000 square feet	$ 2.69	$ 2.56	
Cost per 1,000 gallons handled daily	$ 1.83	$ 3.42	
Cost per quart, cents	.0457	.0855	

[a] From Tables 18 to 24.

used 39 square feet of space per 1,000 gallons of milk daily for bottle-case cleaning and storage, or about half as much as Plant X (81 square feet). Plant X used 21 square feet more per 1,000 gallons for bottling than Plant Y.

Plant X had a total of 11,948 square feet (adjusted) of space of which 8,697 square feet were used in plant operations and 3,251 square feet for selling and delivery. The total cost of space for plant operations averaged $23.38 per day. This averaged $1.83 per 1,000 gallons of milk, or .0457 cents per quart (Table 3).

Space costs per 1,000 gallons for Plant X were about half those for Plant Y. Plant X handled about four times the volume of Plant Y in twice the area; unit-space costs per 1,000 square feet were about the same for the two plants.

From the standpoint of over-all operations, space costs for both Plants X and Y were very low, Plant Y averaging less than one-tenth cent per quart, while Plant X averaged about one-twentieth cent per quart.

Equipment Costs

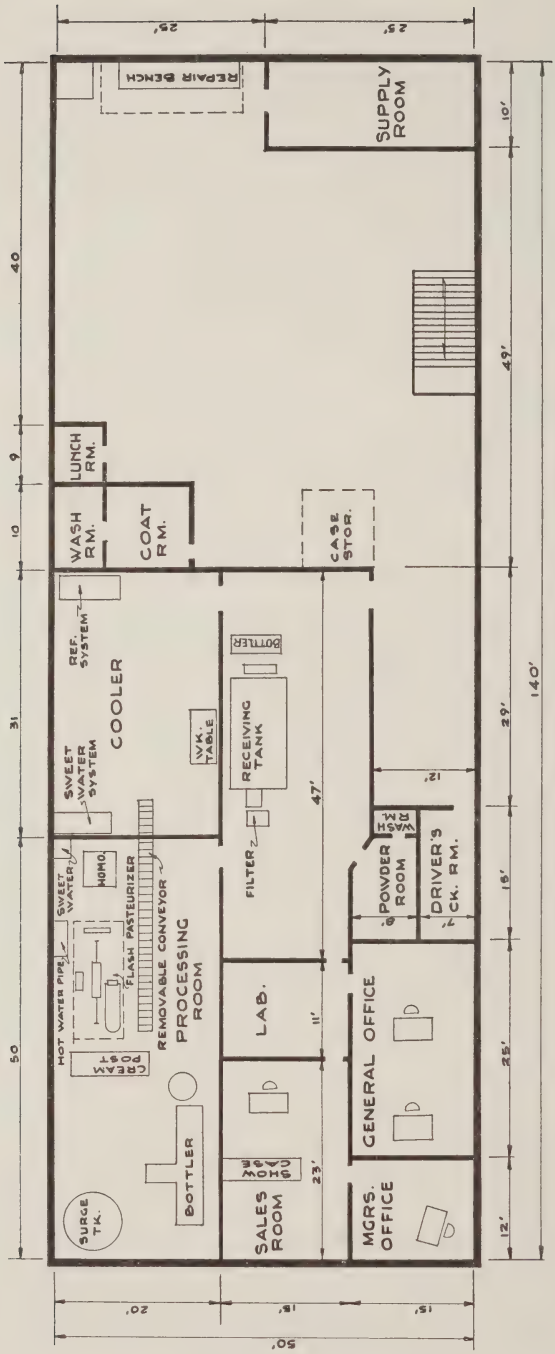
Under usual circumstances, plants handling a large volume of milk and having a good plant layout are able to use their equipment much more efficiently than plants with a small volume. Unit equipment costs for Plant X of $2.69 per 1,000 gallons were only about two-fifths of those for Plant Y, $6.90 per 1,000 gallons (Table 4).

Plant X was far more successful than Plant Y in holding down its unit equipment cost for pasteurizing milk. Its unit expenditure for pasteurizing was only about one-fourth that of Plant Y. In handling refrigeration costs, Plant X was also more efficient, its unit cost being

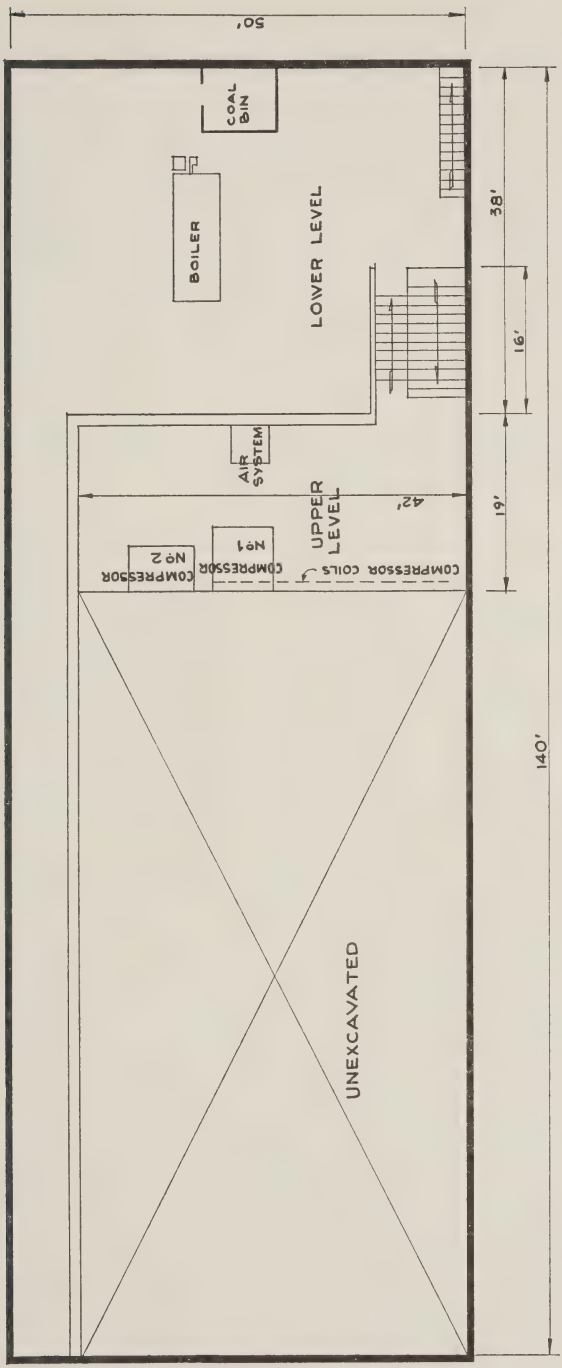
Table 4. — Elements of Equipment Costs per 1,000 Gallons[a]

	Plant X	Plant Y
Intermediate processes		
Steam power	$ .125	$ .320
Refrigeration	.329	.902
Sweet-water system	.064	.449
Wash tank	.021	.055
Surge tank	.044	.298
Pressure-vacuum system	.038	.074
Sanitary pipe	.060	.049
Direct to principal processes		
Receiving	.445	.554
Clarifying and filtering	.276	.098
Pasteurizing	.662	2.376
Homogenizing	.191	.662
Bottling	.438	1.067
Total	$2.693	$6.904

[a] From Table 25.



Layout of the main floor of Plant Y. (Fig. 3)



Layout of the basement of Plant Y. (Fig. 4)

about one-third that of Plant Y. An underlying cause for the greater efficiency of Plant X in pasteurizing and refrigeration was the larger volume handled.

In use of equipment for bottling, Plant X was again more efficient. With its large volume and two working shifts, Plant X could use its bottling equipment more hours per day. As a result, the unit cost for Plant X was less than one-half that of Plant Y. Plant X in 1946 was operating its equipment two shifts a day, while Plant Y needed less than one full shift to receive, process, and store its milk.

After this study was made, big increases in sales of milk in paper containers forced officials of Plant X to build a larger plant. In 1951 the new plant was handling 225 percent of the volume of milk handled by Plant X in 1946. The new plant was using labor and equipment even more efficiently than Plant X was in 1946. Volume of Plant Y was only slightly higher in 1951 than in 1946.

Electric-Power Requirements and Power Costs

Since electric power is now used for most market-milk operations needing power, electric costs must be considered in any program aimed at efficiency. Plant X had 19 electric motors with a total of 124.75 rated horsepower while Plant Y had 14 electric motors with a total of 69.75 rated horsepower.

Plant X used a total of 1,805 horsepower-hours (rated horsepower times actual hours of operation) daily, compared with 588 horsepower-hours used by Plant Y (Table 5). In both plants refrigeration and homogenizing required the most power.

Plant X employed power more efficiently than Plant Y. It averaged 142 horsepower-hours per 1,000 gallons of milk compared with 181 hours per 1,000 gallons for Plant Y. The major difference in the relative efficiency of the two plants was in the use of electricity for refrigeration. Plant X used 92.9 horsepower-hours per 1,000 gallons. Plant Y with 126.8 horsepower-hours required 36 percent more power per 1,000 gallons than Plant X (Table 28). The refrigeration plant of Plant X was operated more nearly to capacity than that of Plant Y.

Plant X was also favored with a lower unit cost for electricity than that paid by Plant Y. Plant X paid $4.759 per 1,000 horsepower-hours compared with $9.602 per 1,000 hours paid by Plant Y. Plant X had a special commercial rate for power because of the large volume used.

As a result of a combination of more efficient use of power and a lower rate, Plant X had average electricity costs of $.674 per 1,000 gallons of milk compared with $1.738 for Plant Y.

Table 5. — Summary of Electric Power and Electric-Power Costs[a]

	Plant X	Plant Y	Your own plant
Receiving			
Total horsepower hours	5.57	22.61	
HPH per 1,000 gallons	.44	6.96	
Cost per 1,000 HPH	$ 4.76	$ 9.60	
Cost per 1,000 gallons	$ .0021	$ .068	
Clarifying and filtering			
Total horsepower hours	94.71	.05	
HPH per 1,000 gallons	7.42	.016	
Cost per 1,000 HPH	$ 4.76	$ 9.60	
Cost per 1,000 gallons	$ .034	$ .0001	
Pasteurizing			
Total horsepower hours	1,238.34	405.78	
HPH per 1,000 gallons	97.12	124.86	
Cost per 1,000 HPH	$ 4.76	$ 9.60	
Cost per 1,000 gallons	$ .462	$ 1.198	
Homogenizing			
Total horsepower hours	233.19	62.85	
HPH per 1,000 gallons	18.29	19.34	
Cost per 1,000 HPH	$ 4.76	$ 9.60	
Cost per 1,000 gallons	$ .0871	$ .1860	
Bottling			
Total horsepower hours	180.78	47.53	
HPH per 1,000 gallons	14.19	14.62	
Cost per 1,000 HPH	$ 4.76	$ 9.60	
Cost per 1,000 gallons	$ .067	$ .140	
Bottle-case cleaning and storage			
Total horsepower hours	1.14	.18	
HPH per 1,000 gallons	.089	.055	
Cost per 1,000 HPH	$ 4.76	$ 9.60	
Cost per 1,000 gallons	$ .0004	$ .0005	
Bottle-case filling and storage			
Total horsepower hours	50.90	47.80	
HPH per 1,000 gallons	3.99	14.71	
Cost per 1,000 HPH	$ 4.76	$ 9.60	
Cost per 1,000 gallons	$ .019	$ .141	
Totals			
Total horsepower hours	1,804.63	588.39[b]	
HPH per 1,000 gallons	142	181	
Cost per 1,000 HPH	$ 4.759	$ 9.602	
Cost per 1,000 gallons	$ .67	$ 1.74	
Cost per quart, cents	.0168	.0435	

[a] From Tables 26 and 27.
[b] Includes 1.59 horsepower-hours going to selling and delivery.

Steam-Power Requirements and Steam Costs

Plant X averaged 736 B.t.u. per gallon of milk compared with 831 B.t.u. for Plant Y (Table 6). The unit steam-power requirements for Plant Y were 13 percent higher than those for Plant X.

Plant X used oil for heat and had an automatic oil burner, while Plant Y used coal. Plant Y's steam-power cost was $3.97 per million B.t.u., or more than two and a half times that for Plant X ($1.48 per million B.t.u.).

With less heat used and with a lower unit cost, Plant X's steam-power cost of $1.09 per 1,000 gallons of milk was considerably less than one-third that of Plant Y ($3.61 per 1,000 gallons). Plant Y used more than double the amount of unit heat for receiving that Plant X

Table 6. — Summary of Steam Power and Steam-Power Costs[a]

	Plant X	Plant Y	Your own plant
Receiving			
Total B.t.u. (1,000's) daily	796	477	
B.t.u. per gallon	62.4	146.7	
Cost per 1,000 B.t.u.	$.00148	$.00397	
Cost per 1,000 gallons	$ .092	$ .582	
Clarifying and filtering			
Total B.t.u. (1,000's) daily	162	19	
B.t.u. per gallon	12.7	5.8	
Cost per 1,000 B.t.u.	$.00148	$.00397	
Cost per 1,000 gallons	$ .019	$ .023	
Pasteurizing			
Total B.t.u. (1,000's) daily	6,180	1,665	
B.t.u. per gallon	484.7	512.3	
Cost per 1,000 B.t.u.	$.00148	$.00397	
Cost per 1,000 gallons	$ .717	$ 2.034	
Homogenizing			
Total B.t.u. (1,000's) daily	160	107	
B.t.u. per gallon	12.5	32.9	
Cost per 1,000 B.t.u.	$.00148	$.00397	
Cost per 1,000 gallons	$ .018	$ .131	
Bottling			
Total B.t.u. (1,000's) daily	1,644	381	
B.t.u. per gallon	129	117.2	
Cost per 1,000 B.t.u.	$.00148	$.00397	
Cost per 1,000 gallons	$ .191	$ .465	
Bottle-case cleaning and storage			
Total B.t.u. (1,000's) daily	441	53	
B.t.u. per gallon	34.6	16.3	
Cost per 1,000 B.t.u.	$.00148	$.00397	
Cost per 1,000 gallons	$ .051	$ .065	
Totals			
Total B.t.u. (1,000's) daily	9,383	2,702[b]	
B.t.u. per gallon	736	831	
Cost per million B.t.u.	$ 1.48	$ 3.97	
Cost per 1,000 gallons	$ 1.09	$ 3.61	
Cost per quart, cents	.0272	.0902	

[a] From Tables 32, 33, 34, and 35.
[b] This does not include 251,000 British thermal units which were charged to selling and delivery.

used. Plant Y, as stated, received milk in cans while Plant X received milk in tanks. More steam was required for washing cans than for cleaning tanks.

SUMMARY AND CONCLUSIONS

Milk-plant operators are being forced to adjust their business operations to changes brought about by large-volume operations resulting from intermarket shipments of milk and increased store sales of milk in paper containers. These adjustments have emphasized the need for greater efficiency in the industry.

To find out what constituted efficiency in the use of labor, space, electric power, and steam power for the operations of market-milk plants and how to measure it, an analysis was made in 1946. Two efficient milk plants, Plant X in Illinois and Plant Y in Minnesota, were studied in detail, and data from several other plants were used for

comparison. The study indicated that the greatest opportunities for improving milk-plant efficiency appeared to lie in: first, increasing volume; second, modernizing the layout of the plant; third, introducing modern equipment; and fourth, limiting the number of products handled.

Efficiency in the use of labor tends to increase as volume increases. This study indicates that a plant bottling 50,000 quarts of milk or more per day, if properly arranged and equipped with modern machinery, usually can operate more efficiently than a plant handling a smaller volume. This was the volume handled by Plant X at the time of the study, while Plant Y handled about a fourth as much. Unit space costs for Plant X were slightly more than half those of Plant Y and unit equipment costs about two-fifths those for Plant Y.

Volume alone, however, is not a dependable measure of efficiency. One plant, Plant J, handled more than four times as much milk as Plant X, yet it used 1,910 man-minutes per 1,000 gallons of milk while Plant X used only 859 man-minutes. One cause of the inefficient use of labor in Plant J was the many items it handled, 41 compared with only 4 handled by Plant X. Also it was practically impossible to arrange equipment properly in Plant J's poor layout.

Labor is usually the most costly factor in any paper-container plant, other than the cost of containers and bottler rentals. In Plant X labor was 29 percent of total plant costs and 72 percent of costs other than containers and bottler rentals; for Plant Y the percentages were 29 and 64 respectively. Plant X was located in a market where wages were higher than in Plant Y's area, and paid $1.45 an hour to Y's $1.20. But even though Plant X paid higher wages, Plant Y's unit labor cost was 32 percent higher than X's and its unit labor requirements 43 percent higher. The greater volume of milk handled by Plant X underlay the difference in efficient use of labor in the two plants.

Space costs per unit are small in many milk plants. In Plant X they averaged $1.83 per 1,000 gallons of milk, or about one-eleventh the cost of labor. In Plant Y they averaged $3.42 or one-eighth the cost of labor. About half of the total saving in the use of floor space was in pasteurizing, where Plant X used only about a fourth as much space per 1,000 gallons of milk as Plant Y.

Unit costs of equipment are usually higher in plants handling only a small volume than in plants handling a larger volume. Thus in Plant X equipment costs averaged $2.69 per 1,000 gallons, or about one-eighth the cost of labor, while in Plant Y costs were $6.90 or one-fourth the cost of labor. Plant X was far more efficient in pasteurizing milk, its unit cost being about one-fourth that of Plant Y.

When, as at present, each machine has its own motor, a large plant has less advantage over a small plant in the use of power than it has in use of space and equipment. A large plant, however, may have a decided advantage over a smaller plant in the rate charged for electricity. Unit power requirements for Plant X were about four-fifths those of Plant Y, but because of its heavy use of electricity, Plant X had an industrial rate of $4.759 per 1,000 horsepower-hours, or about half that of Plant Y. As a result of somewhat greater efficiency and materially lower electric rates, Plant X's cost for electricity, $.674 per 1,000 gallons of milk, was only about two-fifths that of Plant Y.

Many milk plants in the country have shifted from coal to oil in order to lower costs. High labor rates combined with increased coal prices have materially increased the costs of generating steam from coal. Plant X used an automatic oil burner for generating steam while Plant Y used coal; Plant X's cost of steam power per million B.t.u. was only two-fifths as much as Plant Y's, and Plant X's cost for steam per 1,000 gallons of milk was less than one-third as much.

Some plant layouts are very wasteful of manpower. Companies that have poor layouts and can afford to do so may find it good business to build new plants and equip them with modern machinery. Savings made in two or three years will often pay for the entire cost of new buildings. Plants that find it difficult to do this can often materially reduce costs through a carefully studied rearrangement of plant layout and the adoption of labor-saving techniques. Modernizing equipment, even without a new layout, will tend to promote greater efficiency.

The most efficient plants studied handled relatively few items, not more than eight or ten. Some items are handled to hold particular outlets, even though at a loss. Under good management some of the unprofitable items can be eliminated.

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APPENDIX: DETAILED DATA ON PLANTS X AND Y

Tables 7 through 60 present a detailed breakdown of the data assembled in the study of Plants X and Y. All the figures were prepared in close cooperation with the managers of the plants, who calculated man-hours for each operation and made cost records available. Most of the material was gathered in 1946.

Plant X, a well-laid-out plant of brick construction, was located in Illinois. At the time of this study it was valued at $65,740. The plant handled 51,000 quarts of milk daily and worked two regular shifts besides a clean-up shift.

Plant Y, in Minnesota, was also of brick but newer and better located than Plant X. It was valued at $38,150. Plant Y had an average daily volume of 13,000 quarts and worked one shift.

Interest computed at 5 percent of the building valuations averaged $3,287 annually for Plant X and $1,908 for Plant Y. Plant Y required fewer repairs than Plant X because it was built more recently. Taxes for Plant Y averaged somewhat more because of its better location.

Both plants handled paper containers exclusively and had a 100-percent wholesale business.

Classification of Costs

Costs for operating market-milk plants are classified as elementary costs, intermediate costs, and principal costs, as shown in Table 7. The sum of the elementary costs equals the sum of the principal costs.[1] Elementary costs for plant operations include: (1) labor, (2) space, (3) equipment, (4) electric power, (5) electric light, (6) fuel, (7) water, (8) bottle supply and rental, (9) administration, and (10) general expense.

General expense includes banking, transportation, telephone, office supplies, and miscellaneous. These expenses were distributed to principal processes and to selling and delivery in the proportion that each item was of the total other than general expense.

Intermediate costs include: (1) refrigeration, (2) sweet-water

[1] This general classification of costs is similar to that used in Pennsylvania Agricultural Experiment Station Bulletin 219, "Milk Marketing in Pennsylvania; Shipping Station Operations," and in Minnesota Agricultural Experiment Station Technical Bulletin 26, "Economic Aspects of Creamery Organization." Costs of plant operations and some selling and delivery costs were grouped together and tabulated in elementary costs. Costs of plant operations, however, include only those for carrying milk from the receiving platform through to cold storage. The cost of loading milk to trucks from cold storage is part of selling and delivery costs. No attempt is made in this publication to analyze selling and delivery costs.

system, (3) steam power, (4) pressure-vacuum system, (5) equipment cleaning, (6) floor cleaning, (7) pipe washing and assembly, (8) surge tank, (9) building heat, and (10) office.

Refrigeration costs include labor, space, equipment, electric power and light, and repairs and maintenance. These costs are charged to pasteurizing and storage.

Table 7. — Classification of Costs for Plant Operations of Market Milk Plants X and Y, 1946[a]

	Plant X costs			Plant Y costs		
	Total daily	Per 1,000 gallons	Per quart	Total daily	Per 1,000 gallons	Per quart
Elementary costs						
Administration[b]	$.....	$.....	$.....	$ 17.25	$ 5.31	$.0013
Labor	276.38	21.68	.0054	141.84	43.64	.0109
Space	32.12	2.52	.0006	16.73	5.15	.0013
Equipment	34.35	2.69	.0007	24.55	7.55	.0019
Electric power	8.59	.67	.0002	5.65	1.74	.0004
Electric light	.44	.03	.0000	.33	.10	.0000
Fuel	7.88	.62	.0001	5.17	1.59	.0004
Water	8.63	.68	.0002	3.21	.99	.0003
Bottle supply and rental	564.79	44.30	.0111	164.58	50.64	.0127
General expense	4.83	.38	.0001	2.78[c]	.85	.0002
Selling and delivery	.....	.....	.....	8.65	2.66	.0006
Total	$938.01	$73.57	$.0184	$390.74	$120.22	$.0300
Intermediate costs (included in principal processes)						
Refrigeration	$ 26.41	$ 2.07	$.0005	$ 9.68	$ 2.97	$.0007
Sweet-water system	1.55	.12	.0000	1.61	.49	.0001
Steam power	13.91	1.09	.0003	11.72	3.61	.0009
Building heat	2.39	.19	.0001	4.38	1.35	.0003
Pressure-vacuum system	2.09	.16	.0000	.37	.11	.0000
Equipment cleaning	37.08	2.91	.0007	12.26	3.77	.0009
Floor cleaning	22.59	1.76	.0004	5.47	1.68	.0004
Pipe washing and assembly	11.78	.92	.0002	2.62	.81	.0002
Surge tank	6.54	.51	.0001	3.20	.99	.0002
Office	8.45	.66	.0002	14.67	4.51	.0011
Principal process costs[d]						
Receiving	$ 27.74	$ 2.18	$.0005	$ 15.63	$ 4.81	$.0012
Clarifying and filtering	11.60	.91	.0002	.95	.29	.0001
Pasteurizing	91.87	7.20	.0018	40.49	12.46	.0031
Homogenizing	10.96	.86	.0002	8.81	2.71	.0007
Bottling	681.56	53.45	.0134	198.09	60.95	.0152
Bottle-case cleaning and storage	20.99	1.65	.0004	2.00	.62	.0002
Bottle-case filling and storage	74.08	5.81	.0015	37.14	11.43	.0028
Subtotal	$918.80	$72.06	$.0180	$303.11	$93.26	$.0233
Selling and delivery	19.21	1.51	.0004	87.63	26.96	.0067
Total	$938.01	$73.57	$.0184	$390.74	$120.22	$.0300

[a] Operating costs for all milk plants increased between 1946 and 1950. Four efficient market-milk plants handling an average of 52,554 quarts of milk daily in paper containers in 1950 averaged 2.85 cents per quart or 49.2 percent higher than the costs (1.91 cents per quart) for these same plants in 1946. Assuming the same proportionate increase in unit costs, those for Plant X in 1950 would have been 2.68 cents per quart and those for Plant Y, 3.48 cents per quart (unit costs for 1946 as shown in Table 11 times 1.492).

[b] For Plant X administrative costs were included under manager as a part of labor; Plant Y had administrative costs in addition to manager, which totaled $17.25 a day.

[c] Includes costs for advertising, donations, and trucking chargeable to selling and delivery for Plant Y. These costs are excluded later, as this study does not include an analysis of selling and delivery.

[d] Elementary costs reallocated.

Sweet-water system costs include labor, space, equipment, and electric power and light. This expense is connected with pasteurizing and is charged to that operation.

Steam-power costs include labor, space, equipment, electric power and light, fuel, water, and repairs and maintenance. These costs are distributed to pasteurizing, equipment cleaning, floor cleaning, and building heat. Building-heat costs are distributed to selling and delivery and to each of the principal processes except cold storage.

Pressure-vacuum system costs include labor, space, equipment cleaning, electric power, and repairs and maintenance. These are charged to bottling.

Costs for equipment cleaning and floor cleaning include labor, water, and steam power. These costs are distributed to surge tank, pipe washing and assembly, receiving, clarifying, pasteurizing, homogenizing, and bottling.

Pipe washing and assembly costs include labor, space, equipment cleaning, and floor cleaning. These are distributed to surge tank, receiving, clarifying, pasteurizing, homogenizing, and bottling.

Surge tank costs include space, equipment, electric power and light, equipment cleaning, floor cleaning, and pipe washing and assembly. These costs are distributed to bottling.

Office costs include labor and space. These costs are distributed to principal processes and to selling and delivery.

The principal-process costs include: (1) receiving, (2) clarifying and filtering, (3) pasteurizing, (4) homogenizing, (5) bottling, (6) bottle-case cleaning and storage, and (7) bottle-case filling and storage.

Receiving, clarifying, pasteurizing, homogenizing, and bottling include each of the following costs:

Labor	Floor cleaning
Space	Pipe washing and assembly
Equipment	Building heat
Electric power and light	Office
Repairs and maintenance	General expense
Equipment cleaning	

In addition to these costs, pasteurizing includes refrigeration, sweet-water system, and steam power. Bottling costs also include costs for bottles and bottler rentals, pressure-vacuum system, surge tank, and bottle storage.

Bottle-case cleaning and storage costs include labor, space, electric power and light, office, building heat, and general expense.

Bottle-case filling and cold-storage costs include labor, space, electric power and light, office, refrigeration, and general expense.

This study does not include a detailed analysis of costs for selling and delivery. In accounting reports, however, certain parts of these costs were intermingled with plant costs. Selling and delivery costs included in the reports for Plants X or Y were route loading, garage, routes, special delivery, salesroom, drivers' checkroom, cream testing, advertising, donations, and other costs.

Tables primarily concerned with costs are 7-9, 18, 25, 29, 30, 32, 33, and 36-60. Others secondarily concerned with costs are 12, 13, 15, 17, 19, 20, 26, and 31.

Daily Labor

Labor was distributed to three groups: principal processes, intermediate processes, and selling and delivery. Labor for intermediate processes was charged to the principal processes and to selling and delivery.

The administrative costs for Plant X were included under manager. Plant Y had administrative costs in addition to the manager; these were distributed to principal processes and to selling and delivery in the proportion of man-minutes of labor in each process to total man-minutes.

Distribution of time and cost of managers. A manager is responsible for keeping the plant in operation. Some operations, like repairs and maintenance, require much of the manager's time while others require little. In the process of allocating a manager's time to operations, it is necessary to consider how his time is used.

In this study two methods were used in allocating the manager's time to operation:

1. His time was distributed in the same proportion that employees' time for each operation was of total employees' time.

2. Only a percentage of the manager's time was distributed as in (1), and the rest was charged to repairs and maintenance.

In 11 of the 15 cost items of Plant X, the manager's time was distributed according to the method described in (1) above. In Plant X pasteurizing took 930 man-minutes of employees' time daily, or 8.48 percent of total employees' time (10,970 man-minutes). Four hundred eighty man-minutes (manager's time) times 0.0848 equals 41 minutes, or the amount of manager's time charged to pasteurizing. The manager's time was distributed in the same way to the other ten operations included in Group 1. A similar procedure was used for the items in Group 1 for Plant Y.

The manager of Plant X estimated that around one-fifth of his time was spent in repairing and maintaining machinery. On a direct proportional basis, 9.79 percent of his time was charged to repairs and maintenance.

On a direct proportional basis, 63 minutes of the manager's time in Plant X were charged to bottle-case cleaning and storage, janitor, and selling and delivery. Actually the manager used only about one-sixth of the time charged for these operations. Hence, 11 minutes of the 63 were charged to these operations, and the remaining minutes (52) were charged to repairs and maintenance, as shown in Group 2 (Table 12).

The manager of Plant Y estimated that around a third of his time was spent in repairing and maintaining machinery. On a direct proportional basis, 242 minutes of the manager's time were charged to bottle-case cleaning and storage, janitor, and selling and delivery. The manager actually used only a little under one-third of his time in these operations and the remaining minutes (166) were charged to repairs and maintenance, as shown in Group 2 (Table 12).

Similar methods were used in distributing the time of the foreman, who was responsible to the manager for looking after plant operations, and of the janitor who spent his time cleaning space not cleaned by other employees.

The following tables deal with the distribution of labor time: 10, 11-15, and 17.

Space

Space costs were distributed to the processes on the basis of floor space used in each process.

The floor space figures used were either actual or adjusted. From an operational viewpoint, space on the first floors of Plant X and Y is more valuable than space in the basement, the second floor, or the garage. As a basis for allocating space costs, it was assumed that 2 square feet of space in the basement and second floor and 2.5 square feet in the garage were equivalent to 1 square foot of space on the first floor. The actual and adjusted space are shown in Tables 23 and 24.

The principal processes to which space costs were distributed were: (1) bottle storage, (2) bottling, (3) bottle-case cleaning and storage, (4) refrigeration, (5) bottle-case filling and storage, (6) receiving, and (7) miscellaneous storage. Together these processes used three-fourths of the space for Plant X's operations.

Space costs for building include repairs, depreciation, interest, insurance, and taxes. Office work of both Plants X and Y was done in

another building, and costs for this space were computed on the same basis as other space costs for these plants.

In addition to the two tables in the text concerning space and space costs, Tables 18-24 deal directly with space. Tables 7, 32, 36, 38, 39, 44, 45, 47, 48, 51-55, and 57-59 also include space.

Distribution of electric power to processes is given in Tables 27 and 28 and distribution of steam power in Tables 34 and 35.

Table 8. — Elements of Labor Costs[a]

	Plant X		Plant Y	
	Man-minutes daily	Total daily costs	Man-minutes daily	Total daily costs
Supervision				
Manager	480	$31.79	480	$14.46
Foreman	1,020	30.78	480	12.01
Intermediate processes				
Janitor	480	9.47	60	.99
Repairs and maintenance	1,080	27.91	30	.62
Steam power	....	.....	105	1.97
Equipment cleaning	1,110	24.68	435	7.77
Floor cleaning	570	12.42	90	1.56
Pipe washing and assembly	300	6.51	60	.99
Office	410	6.81	960	12.67
Principal processes				
Receiving	60	1.24	210	3.80
Pasteurizing	930	21.40	210	4.23
Clarifying and filtering	60	1.30	....	.....
Homogenizing	90	1.95	60	1.19
Bottling	1,380	29.20	510	10.36
Bottle-case cleaning and storage	690	14.04	60	1.00
Bottle-case filling and storage	2,520	51.00	1,140	20.30
Selling and delivery	270	5.88	2,310	47.92
Total	11,450	$276.38	7,200	$141.84

[a] Administrative costs for Plant Y, not included in this table, are included in Table 7.

Table 9. — Distribution of Labor and Labor Costs to Principal Processes

	Plant X			Plant Y				
	Total man-minutes	Daily costs		Total man-minutes	Daily costs			
		Total	Per 1,000 gallons		Direct[a]	Administration[b]	Total	Per 1,000 gallons
Principal processes								
Receiving	676	$16.47	$ 1.29	411	$ 8.02	$ .98	$ 9.00	$ 2.77
Clarifying and filtering	265	6.47	.51	17	.30	.04	.34	.10
Pasteurizing	2,286	58.51	4.59	713	14.86	1.71	16.57	5.10
Homogenizing	256	6.28	.49	220	4.39	.53	4.92	1.51
Bottling	3,591	88.84	6.97	973	20.64	2.33	22.97	7.07
Bottle-case cleaning and storage	811	17.66	1.38	77	1.36	.18	1.54	.47
Bottle-case filling and storage	3,070	70.48	5.53	1,581	30.05	3.79	33.84	10.41
Subtotal—plant operations	10,955	$264.71	$20.76	3,992	$ 79.62	$ 9.56	$ 89.18	$27.44
Selling and delivery	495	11.67	.92	3,208[c]	62.22	7.69	69.91	21.51
Total	11,450	$276.38	$21.68	7,200	$141.84	$17.25	$159.09	$48.95

[a] Includes costs for minutes of labor for Plant Y.
[b] Administrative costs for Plant X were included with direct costs.
[c] Includes cream test.

Table 10. — Distribution of Labor to Processes: Man-Minutes per 1,000 Gallons of Milk[a]

	Receiving	Clarifying and filtering	Pasteurizing	Homogenizing	Bottling	Bottle-case cleaning and storage	Bottle-case filling and storage	Total
Plant X								
Direct labor	4.7	4.7	72.9	7.1	108.2	54.1	197.6	449.3
Manager	.2	.2	3.2	.3	4.7	.5	8.6	17.7
Foreman	.4	.6	7.3	.5	12.2	6.0	22.0	49.0
Janitor	.4	.3	1.2	.2	2.0	.5	1.7	6.3
Repairs and maintenance	2.1	2.1	10.4	2.1	52.1	...	....	68.8
Refrigeration	....	...	38.9	....	...	...	1.8	40.7
Pressure-vacuum system	....	...	....	....	2.9	...	....	2.9
Sweet-water system	....	...	.7	....	....	...	....	.7
Steam power	....	...	1.6	....	....	...	....	1.6
Equipment cleaning	13.8	8.3	30.4	5.6	42.4	...	....	100.5
Floor cleaning	12.1	1.8	4.2	2.1	22.0	...	....	42.2
Pipe washing and assembly	17.1	1.2	2.4	1.5	6.1	...	....	28.3
Surge tank	....	...	....	....	11.1	...	....	11.1
Bottle storage	....	...	....	....	7.3	...	....	7.3
Building heat	.2	...	....	....	.2	.2	....	.6
Office	2.0	1.4	6.0	.8	10.5	2.4	9.0	32.1
Total	53.0	20.6	179.2	20.2	281.7	63.7	240.7	859.1
Plant Y								
Direct labor	64.6	...	64.6	18.5	156.9	18.5	350.8	673.9
Manager	4.6	...	4.6	1.2	11.4	.3	25.5	47.6
Foreman	10.5	...	10.5	3.1	25.2	3.1	56.3	108.7
Janitor	.3	...	.6	.3	.9	.3	1.2	3.6
Repairs and maintenance	1.2	...	7.4	1.2	28.3	...	....	38.1
Refrigeration	....	...	20.3	....	....	...	2.5	22.8
Pressure-vacuum system	....	...	....	....	1.2	...	....	1.2
Steam power	....	...	18.8	....	...	...	....	18.8
Equipment cleaning	17.5	...	69.5	34.8	34.8	...	....	156.6
Floor cleaning	14.8	.6	9.2	1.8	7.1	...	....	33.5
Pipe washing and assembly	4.9	4.3	5.2	4.3	2.5	...	....	21.2
Surge tank	....	...	....	....	19.1	...	....	19.1
Bottle storage	....	...	....	....	.9	...	....	.9
Building heat	4.6	.3	3.1	.6	3.4	.9	....	12.9
Office	3.4	...	5.5	1.8	7.7	.6	50.2	69.2
Total	126.4	5.2	219.3	67.6	299.4	23.7	486.5	1,228.1

[a] Computed from Table 11.

Table 11. — Distribution of Labor to Processes: Total Man-Minutes[a]

	Receiving	Clarifying and filtering	Pasteurizing	Homogenizing	Bottling	Bottle-case cleaning and storage	Bottle-case filling and storage	Total
Plant X								
Direct labor	60	60	930	90	1,380	690	2,520	5,730
Manager	3	3	41	4	60	6	110	227
Foreman	5	8	93	6	155	77	280	624
General labor	5	4	15	2	25	6	22	79
Repairs and maintenance	27	27	133	27	664	...	....	878
Refrigeration	..	..	496	..	....	...	23	519
Pressure-vacuum system	..	..	..	..	37	...	....	37
Sweet-water system	..	..	9	..	....	...	....	9
Steam power	..	..	20	..	....	...	....	20
Equipment cleaning	176	106	387	71	541	...	....	1,281
Floor cleaning	154	23	54	27	281	...	....	539
Pipe washing and assembly	219	16	31	19	78	...	....	363
Surge tank	..	..	..	..	141	...	....	141
Bottle storage	..	..	..	..	93	...	....	93
Building heat	2	..	..	..	2	2	....	6
Office	25	18	77	10	134	30	115	409
Total	676	265	2,286	256	3,591	811	3,070	10,955
Plant Y								
Direct labor	210	..	210	60	510	60	1,140	2,190
Manager	15	..	15	4	37	1	83	155
Foreman	34	..	34	10	82	10	183	353
Janitor	1	..	2	1	3	1	4	12
Repairs and maintenance	4	..	24	4	92	...	....	124
Refrigeration	..	..	66	..	....	...	8	74
Pressure-vacuum system	..	..	..	..	4	...	....	4
Steam power	..	..	61	..	....	...	....	61
Equipment cleaning	57	..	226	113	113	...	....	509
Floor cleaning	48	2	30	6	23	...	....	109
Pipe washing and assembly	16	14	17	14	8	...	....	69
Surge tank	..	..	..	..	62	...	....	62
Bottle storage	..	..	..	..	3	...	....	3
Building heat	15	1	10	2	11	3	....	42
Office	11	..	18	6	25	2	163	225
Total	411	17	713	220	973	77	1,581	3,992

[a] See pages 25 to 28 for method of allocating time of intermediate processes to final processes.

Table 12. — Distribution of Time and Cost of Manager

	Employees' time		Distribution of manager's time unadjusted	Percent assigned to manager	Distribution of manager's time adjusted	Assigned to repairs and maintenance	Total daily costs
	Minutes daily	Percent of total					
Plant X							
Group 1							
Receiving	60	.55	3	100	3	..	$ .17
Clarifying	60	.55	3	100	3	..	.17
Pasteurizing	930	8.48	41	100	41	..	2.70
Homogenizing	90	.82	4	100	4	..	.26
Bottling	1,380	12.57	60	100	60	..	4.00
Bottle-case filling and storage	2,520	22.97	110	100	110	..	7.30
Foreman	1,020	9.30	45	100	45	..	2.96
Equipment cleaning	1,110	10.12	48	100	48	..	3.22
Floor cleaning	570	5.20	25	100	25	..	1.65
Pipe washing and assembly	300	2.73	13	100	13	..	.87
Office[a]	410	3.74	18	100	18	..	1.19
Subtotal	8,450	77.03	370	...	370	..	$24.49
Group 2							
Bottle-case cleaning and storage	690	6.29	30	20	6	24	.40
Janitor	480	4.38	21	10	2	19	.14
Route loading	270	2.46	12	25	3	9	.19
Repairs and maintenance							
Direct	1,080	9.84	47	100	(b)	47	....
From other operations	.....	....	..	...	..	52	6.57
Subtotal	2,520	22.97	110	...	11	99	$ 7.30
Total	10,970	100.00	480	...	381	99	$31.79
Plant Y							
Group 1							
Receiving	210	3.13	15	100.00	15	..	$ .45
Pasteurizing	210	3.13	15	100.00	15	..	.45
Homogenizing	60	.89	4	100.00	4	..	.13
Bottling	510	7.59	37	100.00	37	..	1.10
Bottle-case filling and storage	1,140	16.97	83	100.00	83	..	2.46
Foreman	480	7.14	34	100.00	34	..	1.03
Boiler	105	1.56	8	100.00	8	..	.23
Equipment cleaning	435	6.47	32	100.00	32	..	.94
Floor cleaning	90	1.34	6	100.00	6	..	.19
Pipe washing and assembly	60	.89	4	100.00	4	..	.13
Subtotal	3,300	49.11	238	.....	238	..	$7.11
Group 2							
Bottle-case cleaning and storage	60	.89	4	20.00	1	3	.03
Other cleaning and odd jobs	60	.89	4	10.00	..	4	....
Office[c]	960	14.29	68	33.33	22	46	.72
Selling and delivery							
Special delivery	180	2.68	13	33.33	4	9	.13
Routes (4)	1,920	28.56	136	33.33	44	92	1.36
Route loading	90	1.34	6	25.00	2	4	.04
Cream testing	120	1.79	9	33.33	3	6	.08
Repairs and maintenance	30	.45	2	100.00	(b)	2	4.99
Subtotal	3,420	50.89	242	.....	76	166	$ 7.35
Total	6,720	100.00	480	.....	314	166	$14.46

[a] In Plant X all of the clerical labor listed under office was under the supervision of the manager.
[b] Distributed to column for repairs and maintenance.
[c] In Plant Y part of the clerical labor under office was not under the manager's supervision.

Table 13. — Distribution of Time and Cost of Foreman

	Plant X		Plant Y			
	Foreman		Man-minutes supervised		Foreman	
	Man-minutes[a]	Daily costs	Total	Percent of total	Man-minutes[b]	Daily costs
Principal processes						
Receiving	5	$ .17	210	6.60	34	$ .86
Pasteurizing	93	2.91	210	6.60	34	.86
Clarifying	8	.25	....	....	..	....
Homogenizing	6	.20	60	1.89	10	.25
Bottling	155	4.90	510	16.04	82	2.09
Bottle-case cleaning and storage	77	2.46	60	1.89	10	.25
Bottle-case filling and storage	280	8.87	1,140	35.85	183	4.67
Intermediate costs						
Janitor	50	1.59	60	1.89	10	.25
Repairs and maintenance	121	3.84	30	.94	5	.12
Equipment cleaning	143	4.53	435	13.68	70	1.78
Floor cleaning	75	2.35	90	2.83	15	.37
Pipe washing and assembly	33	1.07	60	1.89	10	.25
Steam power	..	....	105	3.30	17	.43
Selling and delivery	19	.60	210	6.60	34	.86
Total	1,065	$33.74	3,180	100.00	514	$13.04

[a] Plant X had three shifts. A full-time foreman worked on the first two shifts, while 60 minutes of the third shift was supervised by the foreman. He was not responsible for the office. Hence the office time (410 man-minutes) plus 1,500 man-minutes of over-all supervision and manager's time was excluded from the total man-minutes (11,450) for Plant X, leaving 9,540 man-minutes of employees' time for which he was responsible. See Table 14.

[b] In Plant Y the foreman was responsible for the thirteen processes which took a total of 3,180 man-minutes each day. His time, 480 minutes plus 34 minutes of the manager's time charged to the supervision of the foreman, was distributed in the same proportion as the time in each of the thirteen operations was to total employees' time. The foreman was not responsible for the office, delivery, and special delivery. Hence this time (3,060 man-minutes), together with that for over-all supervision (960 man-minutes), was excluded from the total of 7,200 man-minutes for Plant Y, leaving 3,180 man-minutes of the employees' time for which he was responsible.

(Table 14 is on page 35.)

Table 15. — Distribution of Time and Costs of Other Cleaning and Odd Jobs

	Plant X					Plant Y				
				Costs					Costs	
	Square feet of floor space[a]	Percent of total	Man-minutes[b]	Total daily	Per 1,000 gallons	Square feet of floor space[a]	Percent of total	Man-minutes[b]	Total daily	Per 1,000 gallons
Principal processes										
Bottle-case cleaning and storage	....	.....	...	....	...	34	1.17	1	....	...
Intermediate processes										
General space[b]	604	15.95	85	$1.79	$.14	875	30.25	21	$ .38	$.12
Repairs and maintenance[c]	220	5.81	31	.65	.05	96	3.32	2	.04	.01
Refrigeration	855	22.58	120	2.53	.20	128	4.43	3	.06	.02
Sweet-water system	64	1.69	9	.19	.02	301	10.40	7	.13	.04
Boiler	40	1.06	6	.12	.01	5	.17	..	....	...
Pressure-vacuum system	72	1.90	10	.21	.02	125	4.32	3	.05	.01
Bottle storage	662	17.48	93	1.96	.15	....	.....	..	....	...
Selling and delivery										
Garage	1,270	33.53	178	3.75	.29	879	30.38	22	.39	.12
Salesroom	....	.....	...	....	...	345	11.93	8	.15	.05
Driver's checkroom	....	.....	...	....	...	105	3.63	3	.05	.01
Total	3,787	100.00	532	$11.20	$.88	2,893	100.00	70	$1.25	$.38

[a] Cleaning was distributed on the basis of floor space cleaned and was weighted according to frequency of cleaning shown in Table 16.

[b] Includes labor for cleaning space not included in operation.

[c] Plant X had a full-time janitor working 480 minutes a day. Plant Y had a part-time janitor who worked 60 minutes a day.

Table 14. — Distribution of Foreman's Labor in Man-Minutes by Shifts for Plant X

	First shift			Second shift			Third shift			Total
	Supervised	Percent of total	Distribution of foreman's time	Supervised	Percent of total	Distribution of foreman's time	Supervised	Percent of total	Distribution of foreman's time	Distribution of foreman's time
Principal processes										
Receiving	30	.6	3	....	....	..	30	3.3	2	5
Clarifying	....	....	..	60	1.6	8	..	....	..	8
Pasteurizing	420	8.7	44	210	5.5	27	300	33.3	22	93
Homogenizing	....	....	..	....	....	..	90	10.1	6	6
Bottling	960	20.0	100	420	10.9	55	..	....	..	155
Bottle-case cleaning and storage	480	10.0	50	210	5.5	27	..	....	..	77
Bottle-case filling and storage	1,890	39.5	198	630	16.4	82	..	....	..	280
Intermediate processes										
Repairs and maintenance	480	10.0	50	480	12.5	63	120	13.4	8	121
Janitor	480	10.0	50	....	....	..	..	....	..	50
Floor cleaning	....	....	..	570	14.8	75	..	....	..	75
Pipe washing and assembly	....	....	..	210	5.5	27	90	10.0	6	33
Equipment cleaning	60	1.2	6	1,050	27.3	137	..	....	..	143
Selling and delivery	....	....	..	....	....	..	270	30.0	19	19
Total	4,800	100.0	501	3,840	100.0	501	900	100.0	63	1,065

(Table 15 is on page 34.)

Table 16. — Weighting of Floor Space Cleaned by the Janitor

	Plant X			Plant Y		
	Actual floor space	Weighting	Floor space adjusted to daily basis	Actual floor space	Weighting	Floor space adjusted to daily basis
	sq. ft.		*sq. ft.*	*sq. ft.*		*sq. ft.*
Principal processes						
Bottle-case storage	...	.....	...	100	cleaned twice weekly	34
Intermediate processes						
General space	604	cleaned daily	604	875	cleaned daily	875
Repairs and maintenance	220	cleaned daily	220	96	cleaned daily	96
Refrigeration	1,709	cleaned three times weekly	855	766	cleaned weekly	128
Sweet-water system	128	cleaned three times weekly	64	...	.....	...
Boiler	80	cleaned three times weekly	40	1,804	cleaned weekly	301
Pressure-vacuum system	143	cleaned three times weekly	72	32	cleaned weekly	5
Bottle storage	662	cleaned daily	662	125	cleaned daily	125
Selling and delivery						
Garage	7,620	cleaned weekly	1,270	2,638	cleaned twice weekly	879
Salesroom	...	.....	...	345	cleaned daily	345
Driver's checkroom	...	.....	...	105	cleaned daily	105
Total	11,166	.....	3,787	6,886	.....	2,893

Table 17. — Distribution of Janitor's Time and Cost Not Directly Chargeable to Operations[a]

	Plant X				Plant Y			
	Man-minutes other than for general labor	Percent of total	Man-minutes	Total costs	Man-minutes other than for general labor	Percent of total	Man-minutes	Total costs
Principal processes								
Receiving	646	5.68	5	$.20	399	5.56	1	$ .14
Pasteurizing	1,965	17.29	15	.60	693	9.65	2	.25
Clarifying and filtering	472	4.15	4	.14	17	.24	..	....
Homogenizing	244	2.15	2	.07	213	2.97	1	.08
Bottling	3,432	30.20	25	1.05	945	13.16	3	.34
Bottle-case cleaning and storage	775	6.82	6	.24	75	1.04	..	.03
Bottle-case filling and storage	2,933	25.80	22	.89	1,536	21.40	4	.55
Intermediate processes								
Office	428	3.77	3	.13	184	2.56	1	.07
Garage	178	1.57	1	.05	22	.31	..	.01
Routes	....	....	..	....	2,302	32.07	7	.81
Special delivery	....	....	..	....	184	2.56	1	.06
Salesroom	....	....	..	....	354	4.93	1	.13
Driver's checkroom	....	....	..	....	6	.08	..	....
Cream testing	....	....	..	....	142	1.98	..	.05
Route loading	292	2.57	2	.09	107	1.49	..	.04
Total	11,365	100.00	85	$3.46	7,179	100.00	21	$2.56

[a] Includes the janitor's time spent in cleaning entrances, hallways, and washrooms.

Table 18. — Elements of Annual Space Costs

	Plant X		Plant Y	
	Annual cost	Percent of total	Annual cost	Percent of total
Depreciation[a]	$2,629.60	26.4	$1,144.50	22.6
Insurance[b]	390.00	3.9	172.65	3.4
Repairs[c]	1,373.40	13.8	301.33	5.9
Taxes	2,271.96	22.9	1,536.84	30.4
Interest[d]	3,287.00	33.0	1,907.50	37.7
Average annual cost	$9,951.96	100.0	$5,062.82	100.0
Average daily cost[e]	31.80	....	16.18	....
Office space[f]	.32	....	.55	....
Subtotal	$32.12	....	$16.73	....
Daily cost per 1,000 square feet of floor space	$ 2.688	....	$ 2.560	....

[a] Plant X was valued at $65,740 and was depreciated at 4 percent annually. Plant Y was valued at $38,150 and was depreciated at 3 percent annually.
[b] Includes fire, glass, and scheduled liability.
[c] Plant Y was built more recently than Plant X and required fewer repairs. Both plants were of brick construction.
[d] Computed at rate of 5 percent annually for both plants.
[e] On basis of 313 days per year.
[f] Estimated cost of office space for clerical help located in another building.

Table 19. — Distribution of Space and Space Costs to Intermediate and Principal Processes

	Plant X		Plant Y	
	Square feet of floor space	Total daily costs	Square feet of floor space	Total daily costs
Intermediate costs				
General space	604	$1.61	875	$2.17
Repairs and maintenance	110[a]	.29	38[a]	.09
Refrigeration	854[a]	2.27	383[a]	.95
Sweet-water system	64[a]	.17	17	.04
Steam power	315[a]	.84	902[a]	2.23
Pressure-vacuum system	72[a]	.19	16[a]	.04
Pipe washing and assembly	303	.81	128	.32
Surge tank	307	.82	145	.36
Bottle storage				
First floor	600	1.60	...	....
Basement	840[a]	2.24	125[a]	.31
Office	...	.32	...	.55
Principal process costs				
Receiving	697	1.85	657	1.63
Pasteurizing	246	.65	431	1.06
Clarifying and filtering	102	.27	21	.05
Homogenizing	123	.33	92	.23
Bottling	1,270	3.38	332	.82
Bottle-case cleaning and storage	920	2.45	100	.25
Bottle-case filling and storage	828	2.20	603	1.49
Miscellaneous	645[a]	1.72	...	....
Salesroom and other	...	....	615	2.61
Garage	3,048[a]	8.11	1,055[a]	1.53
Total	11,948	$32.12	6,535	$16.73

[a] From an operational viewpoint, space on the first floors of Plant X and Y was more valuable than space in the basement, the second floor, or the garage. As a basis for allocating space costs, it was assumed that 2 square feet of space in the basement and second floor and 2.5 square feet in the garage were equivalent to 1 square foot of space on the first floor. The actual and adjusted space are shown in Tables 23 and 24.

Table 20. — Final Distribution of Space and Space Costs to Principal Processes

	Plant X			Plant Y		
	Square feet of floor space	Costs		Square feet of floor space	Costs	
		Total daily	Per 1,000 gallons		Total daily	Per 1,000 gallons
Receiving	976	$ 2.63	$ .21	846	$2.17	$ .67
Pasteurizing	1,435	3.86	.30	1,412	3.61	1.11
Clarifying and filtering	317	.85	.07	48	.12	.04
Homogenizing	168	.45	.03	166	.42	.13
Bottling	3,684	9.90	.77	870	2.23	.69
Bottle-case cleaning and storage	1,035	2.78	.22	128	.33	.10
Bottle-case filling and storage	1,082	2.91	.23	866	2.22	.68
Subtotal	8,697	$23.38	$1.83	4,336	$11.10	$3.42
Selling and delivery	3,251	8.74	.69	2,199	5.63	1.73
Total	11,948	$32.12	$2.52	6,535	$16.73	$5.15

Table 21. — Distribution of Space to Processes: Total Square Feet

	Receiving	Clarifying and filtering	Pasteurizing	Homogenizing	Bottling	Bottle-case cleaning and storage	Bottle-case filling and storage	Total
Plant X								
Direct space	697	102	246	123	1,270	920	828	4,186
General space	35	25	105	13	183	42	152	555
Repairs and maintenance	2	11	2	2	56	...	...	73
Refrigeration	..	..	848	..	....	...	39	887
Sweet-water system	..	..	64	..	....	...	...	64
Boiler	..	..	193	..	....	...	...	193
Pressure-vacuum system	..	..	....	..	74	...	...	74
Equipment cleaning	4	2	8	2	11	...	...	27
Floor cleaning	10	1	4	2	17	...	...	34
Pipe washing and assembly	163	12	23	14	58	...	...	270
Surge tank	..	..	....	..	348	...	...	348
Bottle storage	..	..	....	..	1,440	...	...	1,440
Building heat	11	2	4	2	21	15	...	55
Office	1	1	4	1	7	2	5	21
Miscellaneous	53	17	78	9	199	56	58	470
Total	976	173	1,579	168	3,684	1,035	1,082	8,697
Plant Y								
Direct space	602	20	379	81	292	100	603	2,077
General space	49	2	85	26	115	9	187	473
Repairs and maintenance	1	..	4	1	17	...	...	23
Refrigeration	..	..	350	..	....	...	46	396
Sweet-water system	..	..	17	..	....	...	...	17
Boiler	..	..	394	..	....	...	...	394
Pressure-vacuum system	..	..	....	..	17	...	...	17
Equipment cleaning	6	..	26	13	13	...	...	58
Floor cleaning	41	1	25	5	20	...	...	92
Pipe washing and assembly	24	20	26	21	13	...	...	104
Surge tank	..	..	....	..	161	...	...	161
Bottle storage	..	..	....	..	125	...	...	125
Building heat	98	4	62	13	69	15	...	261
Office	1	..	2	1	3	...	5	12
Miscellaneous storage	24	1	42	5	25	4	25	126
Total	846	48	1,412	166	870	128	866	4,336

Table 22. — Distribution of Space to Processes: Square Feet per 1,000 Gallons of Milk[a]

	Receiving	Clarifying and filtering	Pasteurizing	Homogenizing	Bottling	Bottle-case cleaning and storage	Bottle-case filling and storage	Total
Plant X								
Direct space	54.67	19.29	8.00	9.64	99.61	72.15	64.94	328.29
General space	2.74	1.96	8.24	1.02	14.35	3.29	11.92	43.57
Repairs and maintenance	.16	.86	.16	.16	4.39	.....	.....	5.74
Refrigeration	.....	....	66.51	....	....	.....	3.06	69.57
Sweet-water system	.....	....	5.02	....	....	.....	.....	5.02
Boiler	.....	....	15.14	....	....	.....	.....	15.14
Pressure-vacuum system	.....	....	.....	....	5.80	.....	.....	5.80
Equipment cleaning	.31	.16	.63	.16	.86	.....	.....	2.16
Floor cleaning	.78	.08	.31	.16	1.33	.....	.....	2.63
Pipe washing and assembly	12.78	.94	1.80	1.10	4.55	.....	.....	21.12
Surge tank	.....	....	.....	....	27.29	.....	.....	27.30
Bottle storage	.....	....	.....	....	112.94	.....	.....	112.90
Building heat	.86	.16	.31	.16	1.65	1.18	.....	4.27
Office	.01	.08	.31	.08	.55	.16	.39	1.63
Miscellaneous storage	4.15	1.33	6.12	.70	15.61	4.39	4.55	36.84
Total	76.46	24.86	112.55	13.18	288.93	81.17	84.86	681.98
Plant Y								
Direct space	185.23	6.15	116.61	24.92	89.9	30.76	185.54	639.11
General space	15.08	.62	26.15	8.00	35.4	2.77	57.54	145.56
Repairs and maintenance	.31	....	1.23	.31	5.2	.....	.....	7.05
Refrigeration	.....	....	107.69	....	....	.....	14.15	121.84
Sweet-water system	.....	....	5.23	....	....	.....	.....	5.23
Boiler	.....	....	121.23	....	....	.....	.....	121.23
Pressure-vacuum system	.....	....	.....	....	5.2	.....	.....	5.20
Equipment cleaning	1.85	....	8.00	4.00	4.0	.....	.....	17.85
Floor cleaning	12.62	.31	7.69	1.54	6.2	.....	.....	28.36
Pipe washing and assembly	7.38	6.15	8.00	6.46	4.0	.....	.....	31.99
Surge tank	.....	....	.....	....	49.5	.....	.....	49.50
Bottle storage	.....	....	.....	....	38.5	.....	.....	38.50
Building heat	30.15	1.23	19.08	4.00	21.2	4.62	.....	80.28
Office	.31	....	.62	.31	.9	.....	1.54	3.68
Miscellaneous storage	7.38	.31	12.92	1.54	7.7	1.23	7.69	38.77
Total	260.31	14.77	434.45	51.08	267.7	39.38	266.46	$1,334.15

[a] Computed from Table 21.

Table 23. — Actual and Adjusted Floor Space

	Plant X			Plant Y		
	Actual space	Ratio of adjustment	Adjusted space	Actual space	Ratio of adjustment	Adjusted space
	sq. ft.		*sq. ft.*	*sq. ft.*		*sq. ft.*
First floor	6,000	none	6,000	4,016	none	4,016
Basement	5,800	2:1	2,900	.....	....	.....
Second floor	.....	....	.....	2,852	2:1	1,426
Garage	7,620	2.5:1	3,048	2,734[a]	2.5:1	1,093
Total	19,420	....	11,948	9,506	....	6,535

[a] Includes 96 square feet assigned to repairs and maintenance.

Table 24. — Distribution of Adjusted Floor Space by Operation

	Plant X			Plant Y		
	Actual space	Ratio of adjustment	Adjusted space	Actual space	Ratio of adjustment	Adjusted space
Basement, Plant X; second story, Plant Y	*sq. ft.*		*sq. ft.*	*sq. ft.*		*sq. ft.*
Refrigeration	1,709	2:1	854	766	2:1	383
Boiler room	630	2:1	315	1,804	2:1	902
Pressure-vacuum system	143	2:1	72	32	2:1	16
Bottle storage	1,680	2:1	840	250	2:1	125
Repairs and maintenance	220	2:1	110	.....	...	.....
Sweet-water system	128	2:1	64	.....	...	.....
General storage	1,290	2:1	645	.....	...	.....
Subtotal	5,800	...	2,900	2,852	...	1,426
Garages	7,620	2.5:1	3,048	2,638	2.5:1	1,055
Repairs and maintenance	.....	...	.....	96	2.5:1	38
Subtotal	7,620	...	3,048	2,734	...	1,093

Table 25. — Elements of Annual Equipment Costs

	Market value	Percent[a] rate of depreciation	Depreciation	Insurance	Repairs	Interest	Total	Costs	
								Per day	Per 1,000 gallons
Plant X									
Receiving tank No. 1	$3,163.29	7	$221.43	$64.39	$47.32	$158.16	$491.30	$1.57	$.123
Receiving tank No. 2	3,989.77	7	279.28	81.21	74.89	199.50	634.88	2.03	.159
Receiving tank No. 3	3,847.91	7	269.35	78.32	63.28	192.40	603.35	1.93	.151
Receiving pump	162.98	14	22.82	3.32	12.47	8.15	46.76	.15	.012
Pasteurizer	7,950.31	20	1,590.06	161.83	493.62	397.52	2,643.03	8.44	.662
Clarifier No. 1	2,501.27	12	300.15	50.91	91.23	125.06	567.35	1.81	.142
Clarifier No. 2	2,483.17	12	297.98	50.54	61.42	124.16	534.10	1.71	.134
Homogenizer	4,126.91	8	330.15	84.00	142.61	206.35	763.11	2.44	.191
Bottling[b]	.....	..	.....	.....	1,749.62	.....	1,749.62	5.59	.438
Boiler	2,495.67	8	199.65	50.80	122.48	124.78	497.71	1.59	.125
Refrigeration	4,532.17	8	362.57	92.25	629.34	226.61	1,310.77	4.19	.329
Sweet-water system	897.16	12	107.66	18.27	85.63	44.87	256.43	.82	.064
Wash tank	325.04	10	32.50	6.62	29.42	16.25	84.79	.27	.021
Surge tank	976.83	7	68.38	19.88	36.92	48.84	174.02	.56	.044
Pressure-vacuum system	675.04	12	81.00	13.74	26.16	33.75	154.65	.49	.038
Sanitary pipe	763.98	20	152.80	15.55	32.91	38.20	239.46	.76	.060
Total	$38,891.50		$4,315.78	$791.63	$3,699.32	$1,944.60	$10,751.33	$34.35	$2.693
Plant Y[c]									
Receiving tank	$3,403.03	7	$238.21	$64.75	$65.72	$170.15	$ 538.83	$1.72	$.529
Receiving pump	74.00	14	10.36	1.41	8.44	3.70	23.91	.08	.025
Milk filter	442.08	14	61.89	8.41	7.42	22.10	99.82	.32	.098
Pasteurizer	7,696.89	20	1,539.38	146.44	279.47	384.84	2,350.13	7.51	2.311
Hot-water pump	358.20	10	35.82	6.82	6.41	17.91	66.96	.21	.065
Homogenizer	4,003.00	8	320.24	76.17	77.43	200.15	673.99	2.15	.662
Bottling[b]	.....	..	.....	.....	1,087.35	.....	1,087.35	3.47	1.067
Boiler	1,849.63	8	147.97	35.19	51.26	92.48	326.90	1.04	.320
Refrigeration	2,809.56	8	224.76	53.46	498.31	140.48	917.01	2.93	.902
Sweet-water system	2,086.06	12	250.33	39.69	61.42	104.30	455.74	1.46	.449
Wash tank	245.85	10	24.59	4.68	14.72	12.29	56.28	.18	.055
Surge tank	1,920.54	7	134.44	36.54	37.13	96.03	304.14	.97	.298
Pressure-vacuum system	305.00	12	36.60	5.80	16.32	15.25	73.97	.24	.074
Sanitary pipe	421.38	20	8.43	8.02	14.10	21.07	51.62	.16	.049
Subtotal	$25,615.22		$3,033.02	$487.38	$2,225.50	$1,280.75	$7,026.65	$22.44	$6.904
Salesroom	3,500.00	10	350.00	66.60	20.87	175.00	612.47	1.96	.603
Laboratory	175.00	10	17.50	3.33	17.63	8.75	47.21	.15	.046
Total	$29,290.22		$3,400.52	$557.31	$2,264.00	$1,464.50	$7,686.33	$24.55	$7.553

[a] See *Dairy Engineering* by A. W. Farrall, p. 336. [b] Bottler rented.

[c] Market-milk plants receiving milk directly from farmers also have scales, butterfat testers, and can washers. Plants X and Y each day received the volume of milk needed for the day's operation from tank trucks or from cans. Plant Y had equipment for testing cream, but this was not considered part of the market-milk operation.

Table 26. — Distribution of Electric Power and Costs

	Rated horse-power	Hours of use daily	Horse-power hours	Costs	
				Total daily	Per 1,000 gallons
Plant X					
Principal processes:					
Receiving	3.00	1.0	3.00	$.01	$.001
Pasteurizing	.75	15.5	11.63	.06	.005
Clarifying					
Clarifier No. 1	3.00	15.5	46.50	....	...
Clarifier No. 2	3.00	15.5	46.50	....	...
Subtotal	....	....	93.00	.44	.03
Homogenizing	15.00	15.5	232.50	1.11	.09
Bottling					
Bottler No. 1	1.50	11.5	17.25	....	...
Bottler No. 2	1.50	11.5	17.25	....	...
Bottler No. 3	1.50	8.0	12.00	....	...
Subtotal	....	....	46.50	.22	.02
Intermediate processes:					
Repairs—maintenance	12.75	1.0	12.75	.06	.005
Refrigeration					
Compressor No. 1	25.00	19.0	475.00	....	...
Compressor No. 2	25.00	19.0	475.00	....	...
Compressor No. 3	10.00	23.0	230.00	....	...
Subtotal	....	....	1,180.00	5.61	.44
Sweet-water system	5.00	15.5	77.50	.37	.03
Boiler	2.00	12.0	24.00	.11	.01
Pressure-vacuum system					
Pressure	4.00	11.5	46.00	....	...
Vacuum	3.50	11.5	40.25	....	...
Subtotal	....	....	86.25	.41	.03
Pipe washing	.25	2.0	.50	....	...
Bottle storage					
Conveyor No. 1	3.00	11.5	34.50	....	...
Conveyor No. 2	5.00	.5	2.50	.19	.01
Total	124.75	....	1,804.63	$8.59	$.67
Plant Y					
Principal processes:					
Receiving					
Pump No. 1	2.00	9.00	18.00	$....	$...
Pump No. 2	2.00	1.50	3.00	....	...
Subtotal	....	....	21.00	.20	.06
Pasteurizing					
Flash	1.50	7.00	10.50	....	...
Hot water	1.50	7.00	10.50	....	...
Subtotal	....	....	21.00	.20	.06
Homogenizing	25.00	2.50	62.50	.60	.18
Bottling	3.25	9.00	29.25	.28	.09
Intermediate processes:					
Refrigeration					
Ammonia system	25.00	16.00	400.00	....	...
Compressor No. 1	1.50	6.00	9.00	....	...
Compressor No. 2	1.50	2.00	3.00	....	...
Subtotal	....	....	412.00	3.96	1.22
Sweet-water system	2.00	7.50	15.00	.14	.04
Boiler					
Motor No. 1	.75	12.00	9.00	....	...
Motor No. 2 (pump)	1.50	.59	.89	....	...
Subtotal	....	....	9.89	.10	.03
Surge tank	2.00	8.50	17.00	.16	.05
Showcase	.25	3.00	.75	.01	.003
Total	69.75	....	588.39	$5.65	$1.74

Table 27. — Distribution of Electric Power to Processes: Total Horsepower Hours Daily

	Receiving	Clarifying and filtering	Pasteurizing	Homogenizing	Bottling	Bottle-case cleaning and storage	Bottle-case filling and storage	Total
Plant X								
Direct	3.00	93.00	11.63	232.50	46.50	....	.....	386.63
Repairs and maintenance	.26	1.27	.26	.26	6.36	....	.....	8.41
Refrigeration	....	....	1,132.92	.....	.....	....	50.90	1,183.82
Sweet-water system	....	....	77.50	.....	.....	....	.....	77.50
Boiler	....	....	14.77	.....	.....	....	.....	14.77
Pressure-vacuum system	....	....	.....	.....	86.51	....	.....	86.51
Bottle storage	....	....	.....	.....	37.00	....	.....	37.00
Equipment cleaning	.28	.17	.63	.11	.87	....	.....	2.06
Floor cleaning	.74	.11	.26	.13	1.35	....	.....	2.59
Building heat	.86	.13	.31	.15	1.57	1.14	.....	4.16
Pipe washing and assembly	.43	.03	.06	.04	.16	....	.....	.72
Surge tank	....	....	.....	.....	.46	....	.....	.46
Total	5.57	94.71	1,238.34	233.19	180.78	1.14	50.90	1,804.63
Plant Y								
Direct	21.00	....	21.00	62.50	29.25	....	.....	133.75
Refrigeration	....	....	364.20	.....	.....	....	47.80	412.00
Sweet-water system	....	....	15.00	.....	.....	....	.....	15.00
Boiler	....	....	4.32	.....	.....	....	.....	4.32
Equipment cleaning	.07	....	.28	.14	.14	....	.....	.63
Floor cleaning	.44	.01	.28	.06	.22	....	.....	1.01
Building heat	1.08	.03	.68	.14	.75	.18	.....	2.86
Pipe washing and assembly	.02	.01	.02	.01	.01	....	.....	.07
Surge tank	....	....	.....	.....	17.16	....	.....	17.16
Total	22.61	.05	405.78	62.85	47.53	.18	47.80	586.80

Table 28. — Distribution of Electric Power to Processes: Horsepower Hours per 1,000 Gallons of Milk[a]

	Receiving	Clarifying and filtering	Pasteurizing	Homogenizing	Bottling	Bottle-case cleaning and storage	Bottle-case filling and storage	Total
Plant X								
Direct	.24	7.29	.91	18.24	3.65	...	.....	30.33
Repairs and maintenance	.02	.10	.02	.02	.50	...	.....	.66
Refrigeration	....	....	88.86	....	....	...	3.99	92.85
Sweet-water system	....	....	6.08	....	....	...	.....	6.08
Boiler	....	....	1.16	....	....	...	.....	1.16
Pressure-vacuum system	....	....	.....	....	6.79	...	.....	6.79
Bottle storage	....	....	.....	....	2.90	...	.....	2.90
Equipment cleaning	.02	.01	.05	.01	.07	...	.....	.16
Floor cleaning	.06	.01	.02	.01	.11	...	.....	.21
Building heat	.07	.01	.02	.01	.12	.09	.....	.32
Pipe washing and assembly	.03	.002	.005	.003	.01	...	.....	.05
Surge tank	....	....	.....	....	.04	...	.....	.04
Total	.44	7.422	97.125	18.293	14.19	.09	3.99	141.55
Plant Y								
Direct	6.46	....	6.46	19.23	9.00	...	.....	41.15
Refrigeration	....	....	112.06	....	....	...	14.71	126.77
Sweet-water system	....	....	4.61	....	....	...	.....	4.61
Boiler	....	....	1.33	....	....	...	.....	1.33
Equipment cleaning	.02	....	.09	.04	.04	...	.....	.19
Floor cleaning	.14	.003	.09	.02	.07	...	.....	.323
Building heat	.33	.01	.21	.04	.23	.06	.....	.88
Pipe washing and assembly	.01	.003	.01	.003	.003	...	.....	.029
Surge tank	....	....	.....	....	5.28	...	.....	5.28
Total	6.96	.016	124.86	19.333	14.623	.06	14.71	180.562

[a] Computed from Table 27.

(Table 29 is on page 45.)

Table 30. — Distribution of Water Costs[a]

	Plant X costs			Plant Y costs		
	Per 1,000 gallons	Total	Percent of total	Per 1,000 gallons	Total	Percent of total
Boiler	$.07	$ .86	10	$.10	$ .32	10
Equipment cleaning	.27	3.45	40	.30	.96	30
Floor cleaning	.34	4.32	50	.59	1.93	60
Total	$.68	$8.63	100	$.99	$3.21	100

[a] Water for both plants was purchased in the cities where the plants were located. Distribution of these costs was based upon estimates made by the managers.

Table 29. — Distribution of Electric Light Costs

	Plant X				Plant Y			
	Watts	Hours of use	Watt hours[a]	Daily costs	Watts	Hours of use	Watt hours[a]	Daily costs
Principal processes:								
Receiving	1,200	9	10,800	$.07	600	12	7,200	$.09
Processing	...	..	.....	...	1,200	2	2,400	.03
Clarifier	140	10	1,400	.01	...	..	...	..
Pasteurizer	350	10	3,500	.02	...	..	...	..
Homogenizer	170	10	1,700	.01	...	..	...	..
Surge tank	430	10	4,300	.03	...	..	...	..
Bottler	1,290	10	12,900	.11	...	..	...	..
Bottle-case cleaning and storage	800	9	7,200	.05	...	..	...	..
Bottle-case filling and storage	600	10	6,000	.04	400	14	5,600	.07
Intermediate processes:								
General space	...	..	.....	..	560	2	1,120	.01
Office	200	12	2,400	.01	...	..	...	..
Sales	...	..	.....	..	160	2	320	.01
Main	...	..	.....	..	320	2	640	.01
Manager's	...	..	.....	..	160	1	160	..
Washrooms	400	12	4,800	.05	...	..	...	..
Entrances	200	12	2,400		...	..	...	..
Bottle storage	400	3	1,200	.01	...	..	...	..
Refrigeration	600	3	1,800	.01	400	1	400	.01
Repair shop	400	6	2,400	.01	...	..	...	..
Boiler room	200	3	600	..	860	2	1,720	.02
Driver's checkroom	...	..	.....	..	200	3	600	.01
Supply room	...	..	.....	..	200	2	400	.01
Garage	...	..	.....	..	1,600	3	4,800	.06
Total	7,380	89	63,400	$.44[b]	6,660	46	25,360	$.33

[a] Obtained by multiplying the wattage in the electric bulbs for each operation by the hours of use.
[b] Includes fractions of less than one-half cent not shown above.

(Table 30 is on page 44.)

Table 31. — Distribution of Time and Costs for Repairs and Maintenance

	Plant X				Plant Y			
	Man-minutes		Costs		Man-minutes		Costs	
	Percent of total[a]	Total[b]	Total daily	Per 1,000 gallons	Percent of total[a]	Total[b]	Total daily	Per 1,000 gallons
Principal processes								
Receiving	2	27	$ .79	$ .06	2	4	$ .10	$ .03
Clarifying or filtering	2	27	.79	.06	..	..	..	..
Pasteurizing	10	133	3.93	.31	12	24	.62	.19
Homogenizing	2	27	.79	.06	2	4	.10	.03
Bottling	50	664	19.66	1.54	45	92	2.35	.73
Intermediate processes								
Refrigeration	30	399	11.80	.93	35	71	1.83	.56
Boiler	2	27	.79	.06	2	4	.10	.03
Pressure-vacuum separator	2	27	.79	.06	2	4	.10	.03
Total	100	1,331	$39.34	$3.08	100	203	$5.20	$1.60

[a] Based upon plant manager's estimate.
[b] Includes direct labor, manager, foreman, and janitor.

Table 32. — Elements of Steam Power Costs

	Plant X costs		Plant Y costs	
	Total daily	Per 1,000 gallons	Total daily	Per 1,000 gallons
Labor				
Manager	$ ..	$ ..	$ .23	$.07
Foreman	..	..	.43	.13
Janitor	.12	.01	.13	.04
Operator	..	..	1.97	.61
Space[a]	2.56	.20	2.23	.69
Equipment	1.59	.12	1.02	.31
Electric power and light	.11	.01	.12	.04
Fuel	7.88	.62	5.17	1.59
Water	.86	.07	.32	.10
Repairs and maintenance	.79	.06	.10	.03
Total	$13.91	$1.09	$11.72	$3.61

[a] Includes miscellaneous storage.

Table 33. — Distribution of Steam Power Costs

	Plant X				Plant Y			
	Heat requirements		Daily costs		Heat requirements		Daily costs	
	Total B.t.u. (1,000's)	Percent of total	Total	Per 1,000 gallons	Total B.t.u. (1,000's)	Percent of total	Total	Per 1,000 gallons
Pasteurizing[a]	5,710	60.86	$8.47	$.66	1,289	43.65	$5.11	$1.57
Equipment cleaning[b]	813	8.66	1.20	.09	204	6.91	.81	.25
Floor cleaning[b]	1,251	13.33	1.85	.15	356	12.06	1.42	.44
Building heat[c]	1,609	17.15	2.39	.19	1,104	37.38	4.38	1.35
Total	9,383	100.00	$13.91	$1.09	2,953	100.00	$11.72	$3.61

[a] Heat requirements for pasteurization equalled pounds of milk times (pasteurizing temperature minus entering milk temperature) times specific heat times (1.00 minus regeneration efficiency). The outgoing hot milk partly heats the incoming cold milk; this is known as regeneration. It is estimated that around 60 percent of the heat is recovered in this way. Formula from *Dairy Engineering* by A. W. Farrall.

Substituting the data for Plant X: 109,650 pounds × (180−40) × .93 × (1.00−.60) = 5,710,572 B.t.u.

Substituting the data for Plant Y: 27,950 pounds × (164−40) × .93 × (1.00−.60) = 1,289,278 B.t.u.

[b] Heat requirements for cleaning equalled (hot-water temperature minus tap-water temperature) times weight of water times (1.00 plus heat loss). Also from *Dairy Engineering* by Farrall.

Substituting the data for cleaning equipment of Plant X: (160−40) × 5,421 × (1.00+.25) = 813,150 B.t.u.

Substituting the data for cleaning equipment of Plant Y: (150−50) × 1,628 × (1.00+.25) = 203,500 B.t.u.

Floor cleaning of Plant X had the following heat requirements: (160−40) × 8,340 × (1.00+.25) = 1,251,000 B.t.u.

Floor cleaning of Plant Y had the following heat requirements: (150−50) × 2,849 × (1.00+.25) = 356,125 B.t.u.

[c] Heat requirements for water and steam used in cleaning floor equalled degree days for location of plant times (cubic feet of space heated divided by 1,000) times steam consumption per degree date times B.t.u. per pound of steam times (1 divided by operating days per year). Formula from *Heating and Air Conditioning* by Allen, Walker, and James, McGraw-Hill, 1946.

Substituting the data for Plant X: 6,287 × 90,000/1,000 × .89 × 1,000 × 1/313 = 1,608,910 B.t.u.

Substituting the data for Plant Y: 7,989 × 48,620/1,000 × .89 × 1,000 × 1/313 = 1,104,468 B.t.u.

Although Plant X reported a pasteurizing temperature of 180° F., at least one authority believes this temperature to be excessively high. If Plant X had used a lower temperature, its unit heat requirements and unit costs for heat would presumably have been less than those reported.

Table 34. — Distribution of Steam Power to Processes: B.t.u. per Gallon of Milk

	Receiving	Clarifying and filtering	Pasteurizing	Homogenizing	Bottling	Bottle-case cleaning and storage	Total
Plant X							
Direct	.....	....	447.84	.....	.....	.....	447.84
Equipment cleaning	8.63	5.18	18.98	3.45	26.35	.....	62.59
Floor cleaning	22.43	3.29	7.92	4.00	40.86	.....	78.50
Pipe washing and assembly	5.18	.39	.71	.47	1.80	.....	8.55
Surge tank	.....	....	.....	.....	12.24	.....	12.24
Building heat	26.20	3.84	9.25	4.63	47.69	34.59	126.20
Total	62.44	12.70	484.70	12.55	128.94	34.59	735.92
Plant Y							
Direct	.....	....	396.62	.....	.....	.....	396.62
Equipment cleaning	6.46	....	26.15	12.92	12.92	.....	58.45
Floor cleaning	40.00	1.23	26.15	5.54	20.00	.....	92.92
Surge tank	.....	....	.....	.....	14.46	.....	14.46
Pipe washing and assembly	1.54	1.23	1.54	1.23	.92	.....	6.46
Building heat	98.76	3.38	61.85	13.23	68.92	16.31	262.45
Total	146.76	5.84	512.31	32.92	117.23	16.31	831.36

Table 35. — Distribution of Steam Power to Processes: Total B.t.u. (1,000's)

	Receiving	Clarifying and filtering	Pasteurizing	Homogenizing	Bottling	Bottle-case cleaning and storage	Total
Plant X							
Direct	...	..	5,710	...	...	...	5,710
Equipment cleaning[a]	110	66	242	44	336	...	798
Floor cleaning[b]	286	42	101	51	521	...	1,001
Pipe washing and assembly[c]	66	5	9	6	23	...	109
Surge tank	...	..	...	...	156	...	156
Building heat[d]	334	49	118	59	608	441	1,609
Total	796	162	6,180	160	1,644	441	9,383
Plant Y							
Direct	...	..	1,289	...	...	...	1,289
Equipment cleaning[a]	21	..	85	42	42	...	190
Floor cleaning[b]	130	4	85	18	65	...	302
Pipe washing and assembly[c]	5	4	5	4	3	...	21
Surge tank	...	..	...	...	47	...	47
Building heat[d]	321	11	201	43	224	53	853
Total	477	19	1,665	107	381	53	2,702

[a] Computed by multiplying percent of man-minutes for each process (Table 42) by total B.t.u. for equipment cleaning (Table 33).

[b] Computed by multiplying percent of space actually cleaned (Table 43) by total B.t.u. for floor cleaning (Table 33).

[c] Total B.t.u. were obtained by multiplying the percent of space used for pipe washing and assembly (Table 43) by the total B.t.u. for floor cleaning (Table 33). Distribution was on the basis of percentage of pipe length used in each process (Table 46).

[d] Computed by multiplying percent of cubic feet used in each process (Table 37) by total B.t.u. for building heat (Table 33).

Table 36. — Elements of Refrigeration Costs[a]

	Plant X costs[b]		Plant Y costs	
	Total daily	Per 1,000 gallons	Total daily	Per 1,000 gallons
Space	$2.27	$ .17	$ .95	$ .29
Equipment	4.19	.33	2.87	.88
Electric power and light	5.62	.44	3.97	1.22
Janitor	2.53	.20	.06	.02
Repairs and maintenance	11.80	.93	1.83	.56
Total	$26.41	$2.07	$9.68	$2.97

[a] The major part (95.7 percent) of refrigeration costs goes for pasteurization. The rest is for the cold-storage room.

[b] A larger volume of milk in Plant X made possible more economical use of space, equipment, and power, but also resulted in more breakdowns, increasing the cost of repairs and maintenance.

Table 37. — Distribution of Costs for Building Heat

	Plant X[a]					Plant Y				
	Cubic feet of heated space	Percent of total	Man-minutes	Daily costs		Cubic feet of heated space	Percent of total	Man-minutes	Daily costs	
				Total	Per 1,000 gallons				Total	Per 1,000 gallons
Principal processes										
Receiving	18,670	20.76	2	$.50	$.04	14,140	29.07	15	$1.27	$ .39
Clarifying	2,730	3.04	..	.07	.01	470	.97	1	.04	.01
Pasteurizing	6,580	7.33	..	.17	.01	8,860	18.25	10	.80	.25
Homogenizing	3,290	3.66	..	.09	.01	1,900	3.91	2	.17	.05
Bottling	34,090	37.82	2	.91	.07	9,870	20.28	11	.90	.28
Bottle-case cleaning and storage	24,640	27.39	2	.65	.05	2,350	4.83	3	.21	.06
Intermediate processes										
Salesroom	.....	.....	..	....	...	8,100	16.66	8	.73	.22
Driver's checkroom	.....	.....	..	....	...	2,930	6.03	3	.26	.08
Total	90,000	100.00	6	$2.39	$.19	48,620	100.00	53	$4.38	$1.34

[a] Plant X had the advantage of a more favorable climate for keeping its heating costs low.

Table 38. — Elements of Costs for Sweet-Water System

	Plant X costs		Plant Y costs	
	Total daily	Per 1,000 gallons	Total daily	Per 1,000 gallons
Space	$ .17	$ .01	$ .04	$ .01
Equipment	.82	.06	1.43	.44
Electric power and light	.37	.03	.14	.04
Janitor	.19	.02	...	...
Total	$1.55	$.12	$1.61	$ .49

Table 39. — Elements of Costs for Pressure-Vacuum System[a]

	Plant X costs		Plant Y costs	
	Total daily	Per 1,000 gallons	Total daily	Per 1,000 gallons
Janitor	$ .21	$ .02	$ .04	$ .01
Space	.19	.01	.23	.07
Equipment cleaning	.49	.04	...	...
Electric power	.41	.03	...	...
Repairs and maintenance	.79	.06	.10	.03
Total	$2.09	$ .16	$ .37	$ .11

[a] Air-pressure and vacuum systems are an automatic device used in forming paper containers before they are paraffined. This is part of the bottling operation and the costs are distributed to bottling.

Table 40. — Elements of Costs for Equipment Cleaning

	Plant X costs		Plant Y costs	
	Total daily	Per 1,000 gallons	Total daily	Per 1,000 gallons
Labor				
Manager	$3.22	$ .25	$ .94	$ .29
Foreman	4.53	.36	1.78	.55
Operator	24.68	1.94	7.77	2.39
Water	3.45	.27	.96	.29
Steam power	1.20	.09	.81	.25
Total	$37.08	$2.91	$12.26	$3.77

Table 41. — Elements of Costs for Floor Cleaning[a]

	Plant X costs		Plant Y costs	
	Total daily	Per 1,000 gallons	Total daily	Per 1,000 gallons
Labor				
Manager	$ 1.65	$ .13	$ .19	$ .06
Foreman	2.35	.18	.37	.11
Operator	12.42	.97	1.56	.48
Water	4.32	.34	1.93	.59
Steam power	1.85	.14	1.42	.44
Total	$22.59	$1.76	$5.47	$1.68

[a] These costs were distributed on basis of floor space cleaned. See Table 43.

Table 42. — Distribution of Costs for Equipment Cleaning

	Plant X						Plant Y					
	Man-minutes for actual cleaning[a]	Percent of total	Man-minutes		Costs		Man-minutes for actual cleaning[a]	Percent of total	Man-minutes		Costs	
			Total	Per 1,000 gallons	Total	Per 1,000 gallons			Total	Per 1,000 gallons	Total	Per 1,000 gallons
Principal processes												
Receiving	150	13.51	176	14	$ 5.01	$ .39	45	10.35	57	17	$1.27	$ .39
Pasteurizing	330	29.73	387	30	11.02	.86	180	41.38	226	69	5.07	1.56
Homogenizing	60	5.41	71	6	2.01	.16	90	20.68	113	35	2.54	.78
Clarifying	90	8.11	106	8	3.01	.24	..	.....	...	..	.....	....
Bottling	460	41.44	541	42	15.36	1.21	90	20.68	113	35	2.53	.78
Intermediate processes												
Surge tank	20	1.80	23	2	.67	.05	30	6.91	38	12	.85	.26
Total	1,110	100.00	1,304	102	$37.08	$2.91	435	100.00	547	168	$12.26	$3.77

[a] The time charged to equipment cleaning for Plant X was 1,110 man-minutes. In addition to this, 48 minutes of the manager, 143 minutes of the foreman, and 3 minutes of the janitor were charged, making a total of 1,304 man-minutes. The total time including that of manager, foreman, and janitor was distributed to the processes on the same basis as the employee's time used for each process. The same method was used in distributing the total time for Plant Y.

Table 43. — Distribution of Costs for Floor Cleaning

	Plant X					Plant Y				
	Floor space actually cleaned	Percent of total	Man-minutes	Costs		Floor space actually cleaned	Percent of total	Man-minutes	Costs	
				Total daily	Per 1,000 gallons				Total daily	Per 1,000 gallons
Principal processes										
Receiving	697	22.87	154	$5.17	$ .40	657	36.39	48	$2.00	$ .61
Pasteurizing	246	8.07	54	1.82	.14	431	23.86	30	1.30	.40
Clarifying and filtering	102	3.35	23	.76	.06	21	1.16	2	.06	.02
Homogenizing	123	4.04	27	.91	.07	92	5.09	6	.28	.09
Bottling	1,270	41.66	281	9.41	.74	332	18.38	23	1.00	.31
Intermediate processes										
Surge tank	307	10.07	68	2.27	.18	145	8.03	10	.44	.13
Pipe washing and assembly	303	9.94	67	2.25	.18	128	7.09	9	.39	.12
Total	3,048	100.00	674	$22.59	$1.77	1,806	100.00	128	$5.47	$1.68

Table 44. — Elements of Costs for Pipe Washing and Assembly

	Plant X costs		Plant Y costs	
	Total daily	Per 1,000 gallons	Total daily	Per 1,000 gallons
Labor				
Manager	$ .87	$.07	$ .13	$.04
Foreman	1.07	.08	.25	.08
Operator	6.51	.51	.99	.30
Space	.81	.06	.32	.10
Equipment cleaning	.27	.02	.54	.17
Floor cleaning	2.25	.18	.39	.12
Total	$11.78	$.92	$2.62	$.81

Table 45. — Elements of Costs for Surge Tank[a]

	Plant X costs		Plant Y costs	
	Total daily	Per 1,000 gallons	Total daily	Per 1,000 gallons
Space	$ .82	$.07	$ .36	$.11
Equipment	1.32	.10	.95	.29
Electric power and light	.03	....	.16	.05
Equipment cleaning	.67	.05	.85	.26
Floor cleaning	2.27	.18	.44	.14
Pipe washing and assembly	1.43	.11	.44	.14
Total	$6.54	$.51	$3.20	$.99

[a] Surge tank costs were distributed to bottling.

Table 46. — Distribution of Costs for Pipe Washing and Assembly

	Plant X					Plant Y				
	Pipe length (feet)	Percent of total	Man-minutes	Costs		Pipe length (feet)	Percent of total	Man-minutes	Costs	
				Total daily	Per 1,000 gallons				Total daily	Per 1,000 gallons
Principal processes										
Receiving	70	53.03	219	$6.24	$.50	28	19.04	16	$.50	$.15
Pasteurizing	10	7.57	31	.89	.07	30	20.41	17	.53	.16
Clarifying	5	3.79	16	.45	.03	24	16.33	14	.43	.13
Homogenizing	6	4.55	19	.54	.04	25	17.01	14	.45	.14
Bottling	25	18.94	78	2.23	.17	15	10.20	8	.27	.09
Intermediate processes										
Surge tank	16	12.12	50	1.43	.11	25	17.01	14	.44	.14
Total	132	100.00	413	$11.78	$.92	147	100.00	83	$2.62	$.81

Table 47. — Elements of Costs for Bottle Storage[a]

	Plant X costs		Plant Y costs	
	Total daily	Per 1,000 gallons	Total daily	Per 1,000 gallons
Space	$3.84	$.30	$.31	$.10
Electric power and light	.20	.02	.01	.00
Janitor	1.96	.15	.05	.02
Total	$6.00	$.47	$.37	$.12

[a] In a plant using single-service containers, the cartons must be bought and stored in quantities sufficient to insure a regular supply.

Table 48. — Elements of Office Costs

	Plant X costs		Plant Y costs	
	Total daily	Per 1,000 gallons	Total daily	Per 1,000 gallons
Labor				
Manager	$1.19	$.09	$1.38	$.42
Janitor	.13	.01	.07	.02
Clerks	6.81	.53	12.67	3.90
Space[a]	.32	.03	.55	.17
Total	$8.45	$.66	$14.67	$4.51

[a] Clerical work for both Plants X and Y was done in offices located in other buildings. The cost of space used for clerical work in these offices was estimated.

Table 49. — Distribution of Office Costs

	Plant X costs		Plant Y costs	
	Total daily	Per 1,000 gallons	Total daily	Per 1,000 gallons
Receiving	$ .50	$.04	$ .16	$ .05
Clarifying	.36	.03	.01	....
Pasteurizing	1.50	.12	.27	.08
Homogenizing	.19	.01	.09	.03
Bottling	2.62	.21	.38	.12
Bottle-case cleaning and storage	.59	.05	.03	.01
Bottle-case filling and storage	2.26	.17	2.44	.75
Selling and delivery	.43	.03	11.29	3.47
Total	$8.45	$.66	$14.67	$4.51

Table 50. — Distribution of General Expense[a]

	Plant X costs		Plant Y costs	
	Total daily	Per 1,000 gallons	Total daily	Per 1,000 gallons
Receiving	$ .14	$.01	$ .11	$.03
Pasteurizing	.47	.04	.29	.09
Clarifying	.06	.00	.01	.00
Homogenizing	.06	.00	.06	.02
Bottling	3.50	.27	1.41	.43
Bottle-case cleaning and storage	.11	.01	.02	.01
Bottle-case filling and storage	.38	.03	.26	.08
Selling and delivery	.11	.01	.62	.19
Total	$4.83	$.37	$2.78	$.85

[a] Includes bank expense, transportation expense, telephone, office supplies, and miscellaneous expenses.

Table 51. — Elements of Receiving Costs

	Plant X costs		Plant Y costs	
	Total daily	Per 1,000 gallons	Total daily	Per 1,000 gallons
Labor				
Administration	$....	$....	$ .98	$.302
Manager	.17	.013	.45	.138
Foreman	.17	.013	.86	.265
Janitor	.20	.016	.14	.043
Operators	1.24	.097	3.80	1.169
Space	1.85	.145	1.63	.502
Equipment	5.68	.445	2.07	.637
Electric power and light	.08	.006	.29	.089
Office	.50	.039	.16	.049
Repairs and maintenance	.79	.062	.10	.031
Equipment cleaning	5.01	.393	1.27	.391
Floor cleaning	5.17	.405	2.00	.615
Pipe washing and assembly	6.24	.489	.50	.154
Building heat	.50	.039	1.27	.391
General expense	.14	.011	.11	.034
Total	$27.74	$2.173	$15.63	$4.810

Table 52. — Elements of Costs for Clarifying and Filtering

	Plant X costs		Plant Y costs[a]	
	Total daily	Per 1,000 gallons	Total daily	Per 1,000 gallons
Labor				
Manager	$ .17	$.013	$....	$....
Foreman	.25	.020	....	....
Janitor	.14	.011	....	....
Operators	1.30	.102	....	....
Space	.27	.021	.05	.015
Equipment	3.52	.276	.31	.096
Electric power and light	.45	.035	....	....
Repairs and maintenance	.79	.062	....	....
Equipment cleaning	3.01	.236	....	....
Floor cleaning	.76	.060	.06	.018
Pipe washing and assembly	.45	.035	.43	.132
Building heat	.07	.005	.04	.012
Office	.36	.028	.05	.016
General expense	.06	.005	.01	.003
Total	$11.60	$.909	$.95	$.292

[a] Plant Y had no clarifier but filtered its milk.

Table 53. — Elements of Costs for Pasteurizing

	Plant X costs		Plant Y costs	
	Total daily	Per 1,000 gallons	Total daily	Per 1,000 gallons
Labor				
Administration	$....	$	$1.71	$.526
Manager	2.70	.212	.45	.138
Foreman	2.91	.228	.86	.265
Janitor	.60	.047	.25	.077
Operators	21.40	1.678	4.23	1.301
Space	.65	.051	1.06	.326
Equipment	8.44	.662	7.56	2.326
Electric power and light	.08	.006	.21	.065
Office	1.50	.118	.27	.083
Repairs and maintenance	3.93	.308	.62	.191
Refrigeration	25.27	1.982	8.56	2.634
Sweet-water system	1.55	.122	1.61	.495
Steam power	8.47	.664	5.11	1.572
Equipment cleaning	11.02	.864	5.07	1.560
Floor cleaning	1.82	.143	1.30	.400
Pipe washing and assembly	.89	.070	.53	.163
Building heat	.17	.013	.80	.246
General expense	.47	.037	.29	.089
Total	$91.87	$7.205	$40.49	$12.457

Table 54. — Elements of Costs for Homogenizing

	Plant X costs		Plant Y costs	
	Total daily	Per 1,000 gallons	Total daily	Per 1,000 gallons
Labor				
Administration	$.....	$	$ .53	$ .163
Manager	.26	.020	.13	.040
Foreman	.20	.016	.25	.077
Janitor	.07	.005	.08	.025
Operators	1.95	.153	1.19	.366
Space	.33	.026	.23	.071
Equipment	2.44	.191	2.10	.646
Electric power and light	1.12	.088	.61	.188
Repairs and maintenance	.79	.062	.10	.031
Equipment cleaning	2.01	.158	2.54	.782
Floor cleaning	.91	.071	.28	.086
Pipe washing and assembly	.54	.042	.45	.138
Building heat	.09	.007	.17	.052
Office	.19	.015	.09	.028
General expense	.06	.005	.06	.018
Total	$10.96	$ .859	$8.81	$2.711

Table 55. — Summary of Physical Factors and Costs for Homogenizing

	Plant X	Plant Y
Labor		
Total man-minutes daily	256	220
Man-minutes per 1,000 gallons	20.1	67.7
Cost per hour	$ 1.47	$ 1.20
Cost per 1,000 gallons	$ .49	$ 1.35
Space		
Total square feet	168	166
Square feet per 1,000 gallons handled daily	13.2	51.1
Cost per 1,000 square feet	$ 2.688	$ 2.560
Cost per 1,000 gallons	$ .035	$ .131
Electric power		
Total horsepower hours daily	233.19	62.85
HPH per 1,000 gallons	18.29	19.34
Cost per 1,000 HPH	$ 4.76	$ 9.60
Cost per 1,000 gallons	$ .0871	$ .1846
Steam power		
Total B.t.u. (1,000's) daily	160	107
B.t.u. per gallon (1,000)	12.5	32.9
Cost per 1,000 B.t.u. daily	$.00148	$.00397
Cost per 1,000 gallons	$ .018	$ .131

Table 56. — Elements of Bottle and Bottler Rental Costs

	Plant X costs		Plant Y costs	
	Total daily	Per 1,000 gallons	Total daily	Per 1,000 gallons
Containers	$498.50	$39.097	$101.32	$31.175[a]
Royalties[b]	50.00	3.922	16.88	5.193
Equipment rent[b]	16.29	1.278	4.79	1.474
Supplies	.....	.....	41.59	12.796
Total	$564.79	$44.297	$164.58	$50.638

[a] Unlike Plant X, Plant Y did not include the costs of supplies such as paraffin with the container costs. These costs for Plant Y averaged $12.796 per 1,000 gallons. Thus container costs for Y averaged $43.971, compared with $39.097 for X. [b] The bottling machines used by Plants X and Y were rented, and paid for by a monthly royalty and a unit cost for each container filled.

Table 57. — Elements of Costs for Bottling

	Plant X costs		Plant Y costs	
	Total daily	Per 1,000 gallons	Total daily	Per 1,000 gallons
Labor				
Administration	$.....	$.....	$ 2.33	$ .717
Manager	4.00	.314	1.10	.338
Foreman	4.90	.384	2.09	.643
Janitor	1.05	.082	.34	.105
Operators	29.20	2.290	10.36	3.187
Space	3.38	.265	.82	.252
Equipment	5.59	.438	3.40	1.046
Electric power and light	.33	.026	.29	.089
Bottles and bottler rentals (from Table 56)	564.79	44.297	164.58	50.640
Office	2.62	.205	.38	.117
Repairs and maintenance	19.66	1.542	2.35	.723
Pressure-vacuum system	2.09	.164	.37	.114
Equipment cleaning	15.36	1.205	2.53	.778
Floor cleaning	9.41	.738	1.00	.308
Pipe washing and assembly	2.23	.175	.27	.083
Surge tank	6.54	.513	3.20	.985
Bottle storage	6.00	.471	.37	.114
Building heat	.91	.071	.90	.277
General expense	3.50	.274	1.41	.434
Total	$681.56	$53.454	$198.09	$60.950

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Table 58. — Elements of Bottle-Case Cleaning and Storage[a]

	Plant X costs		Plant Y costs	
	Total daily	Per 1,000 gallons	Total daily	Per 1,000 gallons
Labor				
Administration	$.....	$.....	$ .18	$ .055
Manager	.40	.031	.03	.009
Foreman	2.46	.193	.25	.077
Janitor	.24	.019	.03	.009
Operators	14.04	1.101	1.00	.308
Space	2.45	.192	.25	.077
Electric power and light	.05	.004	....	....
Office	.59	.046	.03	.009
Building heat	.65	.051	.21	.065
General expense	.11	.009	.02	.006
Total	$20.99	$1.646	$2.00	$.615

[a] Milk in paper containers is usually packed in wooden boxes holding 20 or 24 units. These boxes are cleaned daily and stored for use the following day.

Table 59. — Elements of Costs for Bottle-Case Filling and Storage

	Plant X costs		Plant Y costs	
	Total daily	Per 1,000 gallons	Total daily	Per 1,000 gallons
Labor				
Administration	$.....	$.....	$ 3.79	$ 1.166
Manager	7.30	.572	2.46	.757
Foreman	8.87	.696	4.67	1.437
Janitor	.89	.070	.54	.166
Operators	51.00	4.000	20.30	6.246
Space	2.20	.173	1.49	.458
Electric power and light	.04	.003	.07	.021
Office	2.26	.177	2.44	.751
Refrigeration	1.14	.089	1.12	.345
General expense	.38	.030	.26	.080
Total	$74.08	$5.810	$37.14	$11.427

Table 60. — Elements of Costs for Selling and Delivery

	Plant X costs		Plant Y costs	
	Total daily	Per 1,000 gallons	Total daily	Per 1,000 gallons
Route loading	$7.01	$ .550	$2.18	$.671
Garage	12.20	.957	3.08	.948
Routes (4)	([a])	....	41.93	12.901
Special delivery	([a])	....	3.61	1.111
Salesroom	([a])	....	8.98	2.763
Driver's checkroom	([a])	....	.58	.178
Cream testing	([a])	....	3.55	1.092
Advertising, donations, and other miscellaneous...	([a])	....	23.72	7.298
Total[b]	$19.21	$1.507	$87.63	$26.962

[a] Not included for Plant X.

[b] The accounting systems of both Plants X and Y included some, but not all, costs for selling and delivery. These costs were included but not analyzed, since this study deals only with plant operations.

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